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ADVANCED COTTON SPINNING

THOMAS THORNLEY

THIRD REVISED EDITION

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ADVANCED COTTON SPINNING

BY

THOMAS THORNLEY

HEAD OF TEXTILE DEPARTMENT, TECHNICAL SCHOOLS, BOLTON; AUTHOR OF "ELEMENTARY COTTON SPINNING," "INTERMEDIATE COTTON SPINNING," "MODERN COTTON ECONOMICS," "MIDDLE PROCESSES OF COTTON MILLS," "COTTON COMBING MACHINES," "COTTON WASTE," AND OTHER TREATISES ON THE COTTON TRADE

BEING A COMPANION VOLUME TO "ELEMENTARY COTTON SPINNING," "COTTON ECONOMICS," AND "MIDDLE PROCESSES OF COTTON MILLS"

WITH ONE HUNDRED AND SEVENTY-SIX ILLUSTRATIONS

THIRD REVISED AND ENLARGED EDITION

LONDON

SCOTT, GREENWOOD & SON

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PREFACE TO THIRD EDITION.

THE author's "Honours" Cotton Spinning having gone out of print it has been decided not to re-issue the same.

The present treatise on "Advanced" Spinning is of a totally different character. It is several times larger, much more complete in its treatment, and contains nothing of the question and answer element.

The more conversant one becomes with the many ramifications of the gigantic cotton trade and the machinery involved in it, the more one realises his own ignorance and what a great deal there is to learn.

At any rate that is how the present author feels after more than fifty years of active, direct, continuous, intense study and connection with the trade in one capacity or another. Almost thirty years of this period have been spent at the Bolton School without ever losing direct personal contact with the trade. There have been almost 900 individual textile students under the writer's supervision at the Bolton School in one session.

A more or less detailed survey of the machinery, processes, principles, commercial transactions, and accessory sections of spinning, weaving, middle processes, cotton waste, doubling and finishing processes, serves to show how very great and how very intricate the matter has become.

As distinct from mechanical descriptions, this work on advanced cotton spinning deals at considerable length with all kinds of problems closely connected with the cotton industry, and it has extended to many more pages than originally intended. The holidays, week-ends, and spare time of several years have been devoted to its preparation by the author.

For convenience in handling Parts I. and II. are published in one volume, while Part III. has been published as a separate volume.

Volume I., or Parts I. and II., therefore treats more especially with processes, manipulation of machinery, arrangement of machinery, correction of derangements, treatment of cotton waste, and various accessory sections.

Volume II., or Part III., deals with "Modern Economics of the Cotton Trade;" transactions in raw cotton, cotton yarn, and cotton cloth; markets, assembly and distribution of materials, and many other features belonging more especially to the commercial side of the business.

Uniform with and concurrently with the two publications above referred to, a third volume is being published under the title of "Middle Processes of Cotton Mills." This book deals with the processes coming between spinning and weaving and those connected with the doubling trade. For example: reeling, bundling, winding, warping, gassing, sizing; ring, flyer, and twiner doublers, preparing, and many allied features. The need for a compendious one-volume treatise on these subjects has often been expressed to the author, and this volume should be of service to the spinning and weaving sides as well as to those connected with the various branches of the doubling trade. Much of the matter of this volume may be also found beneficial by people connected with textiles other than cotton.

It is hoped and believed that these volumes will be of service and interest to numerous individuals connected with the cotton trade; serving as a basis for reference and further investigation along particular lines in any specific branch.

While calculations are by no means omitted, they do not form any strong feature in these three volumes, since that side of the business is somewhat fully dealt with in "Cotton Calculations" by the present author as a separate volume, first issued some years ago, but recently revised and enlarged.

While the material of these three volumes may be regularly referred to as a basis, the author recommends those of his readers who wish to keep fully up to date on these matters to refer as occasion serves to the pages of the various journals or newspapers dealing especially with current cotton topics.

Articles, lectures, market reports, machinery descriptions, and other features of a most able character are often reproduced in these publications.

The author tenders his sincere thanks to every individual who may have helped in any way in the preparation of this treatise, and also to machinery firms who have helped. Such assistance is also duly acknowledged in the context.

THOMAS THORNLEY.

BOLTON, *August*, 1923.

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PART I.

CHAPTER I.

PRACTICAL MANIPULATION OF BLOW-ROOM MACHINERY.

Erection of Hopper Bale Opener.

LEFT-HAND parts marked A1, A3, and all odd numbers starting at feed-end; right-hand parts A2, A4, and all even numbers upwards. Right hand means standing at feed end and looking towards the face of machine. All parts to be well cleaned.

Position of machine accurately determined from plan to suit all requirements of driving shafts, space provided, connections to mixing lattices or other details.

Place the sides of delivery and feed on their feet, firmly connect these, and fix front, back, and other stretchers or cross-bars in position. Place pedestals of stripper in position, then the stripper itself, and now be sure the machine is adjusted correctly to line, counter, or motor shaft, and is levelled both ways to spirit level.

Attend now to spiked lifting lattice and its details starting with the undercasing, grid, and under-grid and making their proper connection to sides of frame. For the spiked lattice itself first fix its bearings properly and the top shaft of lattice, then draw out the shaft and again replace with the spiked lattice thereon.

Lattice blocks to be set so they will work in centre of lattice leathers. In this work the lattice shaft may be put through the lattice, and then shaft and lattice bodily lifted in position with adequate assistance.

Bottom lattice blocks to be now put in the bottom end of lattice and bearings fitted for bottom shaft of this lattice.

Spiked roller sides now fitted on delivery sides and set properly square. Spiked roller and wiper roller lifted into their bearings, with spiked roller parallel with lifting lattice and possibly $\frac{3}{4}$ inch away. Wiper roller set parallel and leather flappers just clear of spiked roller.

Casings fixed over spiked roller and stripper, and fan in its position and freely working. Lattice piecings to work proper way, all gearing, belts, ropes, casings, and pulleys properly applied.

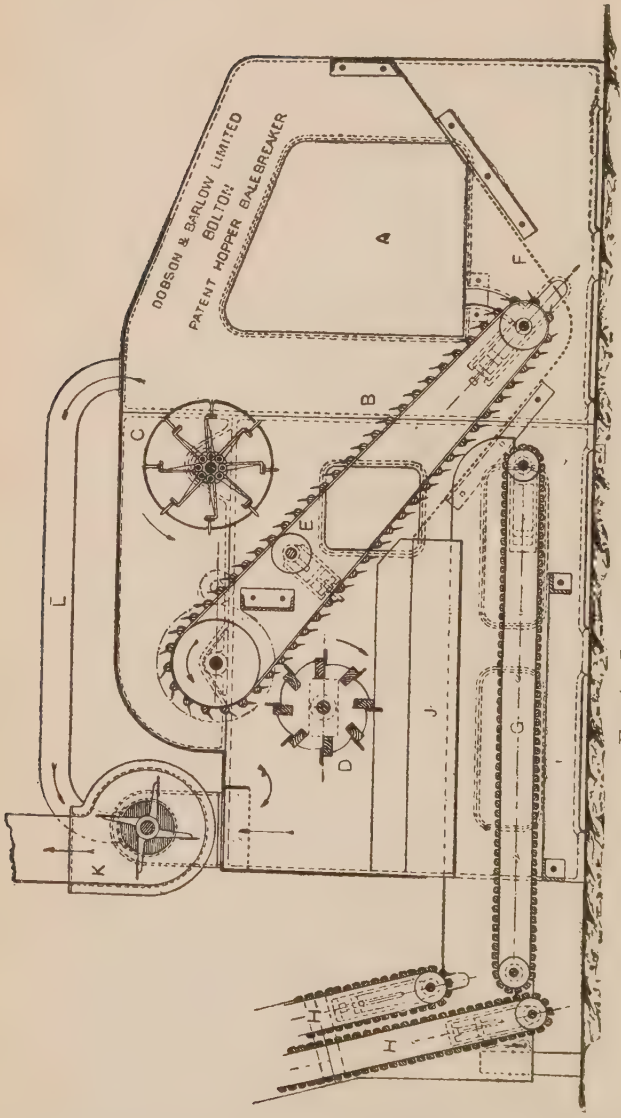


FIG. 1.—Improved hopper bale breaker.

Reference Letters.

A Feed-box.
B Lifting lattice.
C Evener roller.
D Stripping roller.
E Lattice tension.
G Bottom delivery lattice.
H Double elevating lattices.
K Dust fan.
L Dust trunk.

As in every other machine before starting the erector will see that all gaiting-up screws and bolts are properly tightened, all bearings

cleaned and lubricated, all lattices, rollers, shafts, fan, pulleys or gearing working freely, and correct adjustments made. A better test for some of these things is to work for 60 or 70 minutes without cotton, feeling at or noting the working of bearings, and especially noting whether the lattices are running centrally and not bearing over much to one side. Should a lattice run too much towards one side, we may try the effect of tightening the lattice on that side and noting result.

Apart from altering any speeds, the spiked roller may be adjusted farther from lifting lattice to give a less amount of opening. At periods varying from two to four months a periodical thorough cleaning or scouring of machine may be given. There will be the usual weekly cleaning, and usual daily or twice daily lubrication of quickly running parts. All bearings, collars, and necks require attention commensurate with amount of cotton dealt with. Droppings from beneath lifting lattice and delivery grids taken away once or twice daily.

Mixing Lattices.

The delivery lattice of bale opener may be connected to the sides of the double elevating lattice, proper stay rods being fitted. Sides of double elevating lattice to be properly parallel, with top and bottom lattice shafts square and level to machine. Apply first one and then the other of the elevating lattices only removing one stay rod at a time.

The top horizontal carrying lattices will probably have their hangers attached as per plan to roof-beams to agree with the breaks in sides of lattices. Bolt lattice sides to hangers and connect by stays and cross-bars. Apply the lattice shafts and level up every way, remove one stay rod at a time and put in the lattices. Driving arrangements and reversing motions may be applied afterwards.

Ropes and Belts for Bale Breaker.

It is well established that wheel gearing is undesirable for bale breakers on account of noise and possibility of breakdown due to dealing with cotton in an unopened and bulky condition. It has been found quite possible to do all the driving by means of ropes and belts, and this has become the general method. For each rope there is usually a tightening arrangement, and the advantage of wheel driving being a more positive drive is not really required, more especially if the cotton from this breaker is made into stack or bin mixings.

The roller bale breakers which preceded the hopper method were noisy and subject to breakdown both in the wheel gearing and in the spikes or flutes of the opening rollers.

Perhaps the most likely part of the hopper bale breaker for any breakage is the spiked lifting lattice, and in some cases it is possible to take this out without removing the framework.

No bale opener should be without a fan to carry away the liberated dust in any direction required.

For American cotton especially, many spinning firms desire the cotton to proceed automatically from bale opener to hopper feeder, and in such cases a filling motion should be applied to keep the amount of cotton in the feed box of the hopper feeder within required limits, neither too much nor too little in the box at one time.

A bale opener should have a large feed box or else a long bottom feed lattice to hold a good quantity of cotton at one time. For practical purposes a hopper bale opener is almost unlimited in productive power—5 or 6 bales per hour of either American or Egyptian cotton being quite possible. In actual practice one machine may not be required to do this owing to other factors, such as the machines it supplies not requiring such a production, or perhaps because the bale breaker is coupled up to a hopper feeder.

Space required, about 10 × 4 feet without allowing for possible extension of feed lattice. Ropes of $\frac{1}{2}$ inch diameter much in use, but sometimes $\frac{3}{8}$ or $\frac{5}{8}$ inch.

Strong Spiked Lattice (Fig. 2).

The cotton is taken up the spiked lattice which is built up on canvas with hardened steel spikes set in varnished oak lags. These spikes are forced in from the outside edge into holes which are only partly drilled through the lags, so that the action of the cotton cannot affect their position.

Fig. 2.

The cotton travelling up this lattice is operated upon by the Evener roller which knocks back the larger pieces and only allows the smaller ones to go forward.

The amount of opening is regulated according to local requirements and the kind of cotton.

Bale Room.

Formerly it was the almost invariable custom to hoist bales up to the third or fourth storey of that wing of the mill devoted to the storing, mixing, and opening of the cotton, and this method is yet occasionally adopted. In many modern mills, the opposite practice has arisen of placing the cotton bales in the lowest room of the

mill, that is, in the cellar below the card-room or blowing-room. In any case, it is a necessary accompaniment of the unloading and storing of the bales that each one shall be weighed, so that its gross weight can be compared with the weight on the invoice. The cotton bale book should contain a record for each bale, of the weight, the number of bands, and the bale marks or identification marks. Note may also be taken of any special circumstances about any bale such as unexpected markings or numbers, or tares in extra bad condition, or strong signs of country damage. As stated, a modern arrangement is to store the bales in a portion of the cellar, which facilitates unloading the bales and trucking them to their proper positions. It is advisable to place together, or in one separate row, all the bales of a certain mark; the exact method or arrangement being adapted to the special requirements of any specific case. Frequently the marks and qualities of the cottons differ so much that they are never blended, but different cottons are set aside for different counts and qualities of yarns, and these cottons are passed through different preparations of machinery.

Cotton Blending.

It is the almost invariable practice in cotton-spinning mills to adopt some method of mixing the cotton from the various bales, even when only one so-called class of cotton is being used, and the yarns to be spun do not differ much in counts, qualities, or style. Perhaps the cheapest, most used, and least troublesome method of cotton mixing that is adopted is to surround the bale breaker with several bales of cotton that are supposed to differ from one another to a greater or lesser extent, and for the operative to transfer a portion of cotton from each bale in succession to this bale breaker or cotton puller. For American cotton especially there are many mills in which the bale breaker is connected with the hopper feeder, and the cotton is given from the first to the second machine automatically, and passed right through the opener without any further handling.

Stack and Bin Mixings.

On the other hand, many firms using American cotton, and most of those mills in which Egyptian cotton is used, adopt the system of making either stack or bin mixings, in which case the cotton has to be picked up by hand at the required time, and is hand fed to the hopper feeder. In the effect that is sought and obtained there is not a great deal of difference between what is termed stack mixing and bin mixing. It is better for a stack mixing of cotton that it should stand a few days before using in order that the cotton shall be sure to be sufficiently dry and to permit the fibres to naturally loosen themselves from one another, since these

precautions help in the subsequent opening and cleaning processes, and especially do they help in maintaining uniformity in the work. Bin mixing has developed in company with the adoption and development of the bale-breaker method of pulling the cotton into moderately sized portions prior to making the mixings. In the stack mixing the cotton stack may be built up in successive layers or cakes, and to properly obtain the benefit, it is necessary to take the cotton afterwards in vertical portions from the face of the mixing, so as to get a portion of cotton from each layer. But in bin mixing, wood, zinc, or iron may be used to divide the mixing room into bins or stalls of the size and number required. An arrangement of mixing lattices connects these bins with the bale breaker so that the cotton may be given to any one of the bins at any time as required.

Assuming that the portions of cotton taken from the various bales placed around the bale breaker are not too large in size, the cotton will be efficiently mixed before entering the bin, and there may be no necessity to take it therefrom in vertical portions, and the layer system need not be perpetuated.

Erection of Hopper Feeder.

As in the case of all other machines it is first necessary to have all the parts thoroughly cleaned of the grease or other substance applied at the machine shop to prevent rusting of the parts during transit and before being erected.

Notice must be taken of the markings made at the machine shop to facilitate the erection and to ensure that everything is put up of the proper hand, as well as in proper consecutive order, although on a machine like a hopper feeder the duplicate parts are so few as to render this precaution much less essential than on such machines as fly-frames and mules.

A start in the actual erection will be made with the framing, and first the lower parts of the sides may be put on their feet and loosely coupled up by the stretchers, to be followed quickly by the higher portions of the machine sides fixed and fastened in much the same manner by the proper brackets.

The parts of the hopper feeder naturally centre around the elevating apron just as they centre around the cylinder of a carding engine, so that immediately the machine sides are erected the top and bottom shafts of the lifting lattice may be fitted in position, levelled all across with the spirit level, and left quite free in the bearings as well as quite level across. These shafts having been made quite right the elevating lattice itself may be put in and care taken to have it turning readily under sufficient tension, and also the lattice must be equally tight on one side or edge with the other.

as otherwise it may give trouble later by working too much towards one side of the machine. When this lattice is driven from the ordinary cone drums of the opener—as it frequently is—a heavily running lattice will place undue strain on the cone belt and lead to uneven work because of its comparatively high surface speed and the resistance of the cotton.

The inclined elevator being fixed up satisfactorily, the equalising and stripping rollers may be placed in position, and having been previously fitted and marked at the machine shop should not give much trouble here. Like the lattice shafts, these rollers should be level across, and working quite free and easy in their bearings. The speeds of elevating lattice and evener depend somewhat upon the weight of lap required and the kind of cotton to be worked. In the same way these conditions largely rule the exact setting of the evener and elevator in regard to distance from each other, the evener being usually adjustable for this purpose.

The stripping roller adjustment will depend somewhat on the type of stripper employed. If it contains spikes these latter should be set just clear of the spikes on the elevator, but in the case of leather flaps on the cylinder sometimes the leathers actually touch the elevator spikes, although such contact wears the leathers. Having finished off with the stripping roller, further attention may be given to the delivery side of the machine, the delivery slide part being tilted to allow the cotton to fall forward towards the opener feed lattice. The delivery details of a hopper feeder vary with the make of machine, but in any ordinary case the fixing of the delivery box with the one or two coarsely fluted delivery rollers should present no particular difficulty.

Some care will be required with special features of different makers, such as the setting of the grate bars under the stripper in some cases. In the case of hopper feeders fitted with the surplus cotton return motion the returning roller or wiper at the top of the reserve delivery box must be adjusted to operate properly on the excess cotton, while permitting the bulk of cotton to freely enter the reserve box.

The lattice at the bottom of the feed box may now be fixed to revolve freely upon its two opposite shafts, and at a suitable tension. Attention may now be turned to the gearing, an important detail of which is the connection to the cone drums for driving the elevator and feed and delivery parts, which is usually done through the medium of a clutch box, or else a fast and loose pulley arrangement, so that the ordinary full-lap stop-motion also stops these parts.

The requisite gearing connections may therefore be made for driving, and also those for linking the knock-off to the lap end. In the case of a fast and loose pulley the belt must be set to bite fully

on the fast pulley when the machine is working, and fully on the loose pulley after knocking off, the latter clearance being quite essential.

In the same way if a clutch is used this clutch must be quite clear when the drop lever of the knock-off motion is down and yet sufficiently deep in gear when the lap is being made, without jamming at bottom of teeth. If an automatic filling motion be used for regulating the supply of cotton to the feed box it will be necessary to build up the proper connections according to the special make of machine, but usually this work is sufficiently simple and straightforward not to need any special description. The regulating or balanced door of this motion must be adjusted and balanced to suit the cotton as it arrives at the feed box, so as to keep this box something like perhaps three-fifths or three-fourths full.

In fixing all lattices regard should be had to the same law that controls the direction of the overlap and piecings of ordinary driving belts, i.e. the butt ends of piecings must not run against but must run off the bowls or pulleys, if smooth running and long life of the belts are desired. Non-lap-over piecings are desirable if possible.

All working parts should be thoroughly greased and oiled, all shafts noted to be quite free in working, all bolts and screws made thoroughly fast, all lattices to work quite true, all covers and guards placed in position, and the machine worked for possibly 60 or 70 minutes without cotton, in order to test and observe the workings.

After a sufficient lapse of time the machine will be further tested with the actual passage of the cotton, and a chief point to check and regulate will be the uniformity of the feed of cotton from hopper to opener.

Manipulation of Hopper Feeder.

When once the machine has been got thoroughly well working it is not likely to give much further trouble unless the character of the cotton be greatly changed, which will be likely to disturb the regular operation of the machine, and either make the lap sheets lighter or heavier as the case may be. As in the case of all these earlier machines, all the bearings of shafts, collars, and necks will require to be cleaned at intervals, dust must be removed from below the reserve box, and daily oiling of the main bearings should be done.

There will, of course, be the regular cleaning up of the machine.

Anyone with experience in starting up new machines knows that it is expedient at first to keep a close watch for any heating

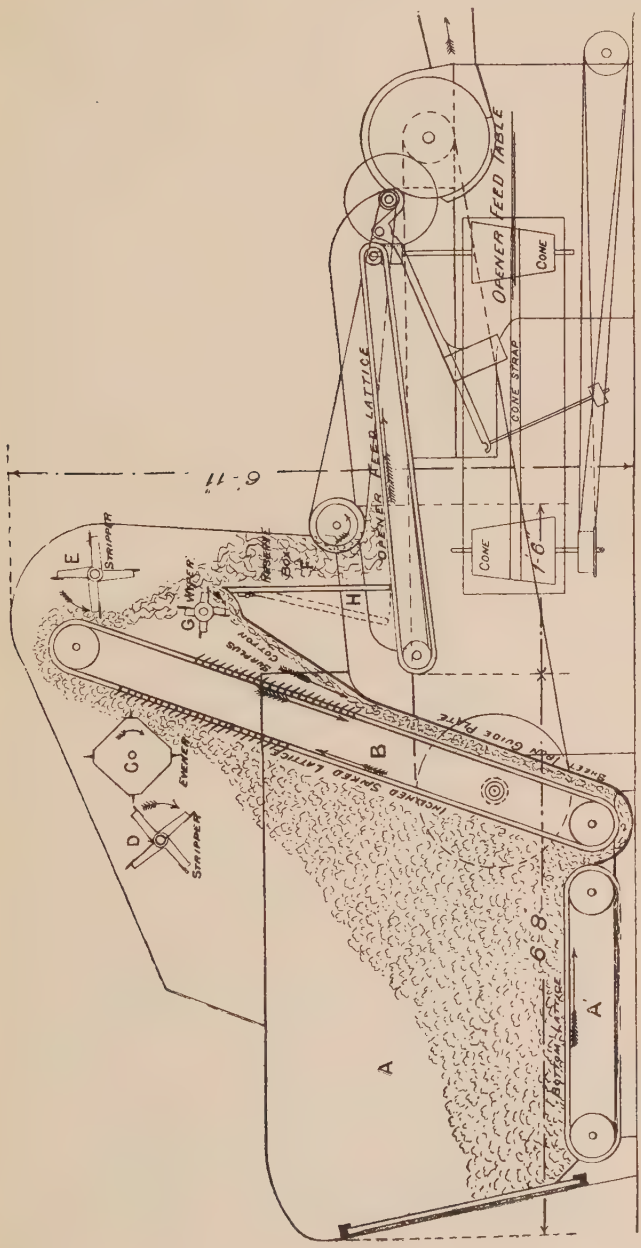


FIG. 3.—Hopper feeder (Lord Bros.). A special feature is the return of surplus cotton to the feed box A. The evener C is cleaned by the extra roller D.

or wearing of parts and hot bearings; the presence of grit or excessive blackening of the oil should be looked at with more or less suspicion.

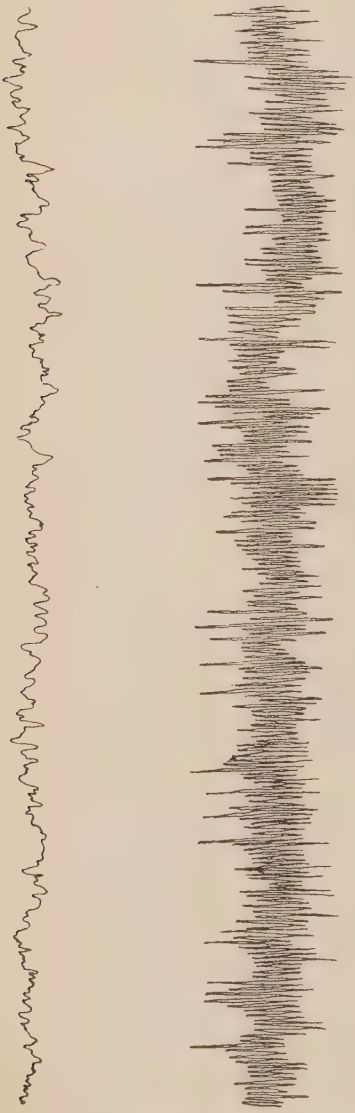


Fig. 4.—Diagrams made by pencil attachment to the regulating finger or pointer of the piano motion to show the difference in regulating produced by a really good hopper feeder.

It is possible to alter one of the train of wheels that drive the elevating lattice if there is reason to think this would improve matters; or the speed of the Evener could be changed by means of change in pulley diameter.

A fair amount of sand and other undesirable matter passes through the bars of the reserve delivery box considering the unopened condition of the cotton at this stage, and this dirt may be taken out every day.

It is a common enough defect with the travelling lattices, now so extensively used in connection with the mixing and blowing-rooms of a spinning mill, for the lattices to run more or less too much on one side, and to remedy this defect the tightening screw on that side may be screwed up, and the lattice tightened up or extended.

It is the usual practice to erect hopper feeders to work in conjunction with openers in which the cotton is formed into laps, but there are yet occasional examples of cotton-opening machines at work without making laps, and delivering the cotton loosely upon the floor. Although of less value in such cases, hopper feeders

may be applied even to such openers, and obviate the necessity for the continual spreading of the cotton on the feed lattice in a uniform manner to prevent choking of the feed rollers. The hopper even in such cases may serve as a labour-saving device. As regards erection, this will be more or less simplified, since there is not the same absolute necessity for real uniformity of feed.

If ever the opener delivers the cotton loosely upon the floor, the next scutcher may be fitted with a hopper feeder.

To Take Elevator Lattice of Hopper Down.

1. First of all the evener and stripper rollers and wiper rollers, if used, must be backed well away from the elevating lattice, taking care to make chisel marks on the bearings of these rollers and on the framing so that it will be easy to replace in same position.

In some cases it may be easiest and best to take these rollers out altogether.

2. In the second place the lifting lattice may be slackened well off by the tensioning screws.

3. The belting piecings may now be unfastened with screw-driver, taking particular care to have some one holding the lattice up to prevent any sudden collapse which would probably damage the spikes and might injure a person.

4. Next the lattice may be pulled round to have the piecing at the bottom and then be withdrawn from the front taking care to have adequate assistance to hold and guide the lattice, to prevent collapse or damage to spikes.

In many cases of taking out lifting lattices it has been found best to draw out the top shaft clean from the end. This releases the lattice and makes it easy to get top drum out. It is difficult to find and undo the lattice piecing, but not to take the top shaft out.

Erection of Crighton Combined Opener and Scutcher.

If there are two or more openers in an order, each one may have a distinction letter as A, B, C. Standing at the feed end of opener each part on right hand may have even numbers as A2, A4, A6, A8, while parts on left hand take odd numbers such as A1, A3, and upwards. All numbers started at feed end. Very important details steady-pinned in exact position. All parts to be thoroughly cleaned. Sometimes the right hand takes the odd numbers.

Start with placing scutcher sides on their feet and bolting the cross-bars or stretchers loosely in position, attaching to these the end-opener side. Beater pedestals to be correctly fixed in position with shoulder of each pedestal set closely to frame side. It is assumed the floor apertures for fans and flues have been marked

accurately on plan, and the fan pipes may be fitted loosely to the framing so that the fan boxes will come directly over the flues. The beater may now be lifted into the pedestals, the framing levelled to spirit level, beater and fan shafts got parallel to counter

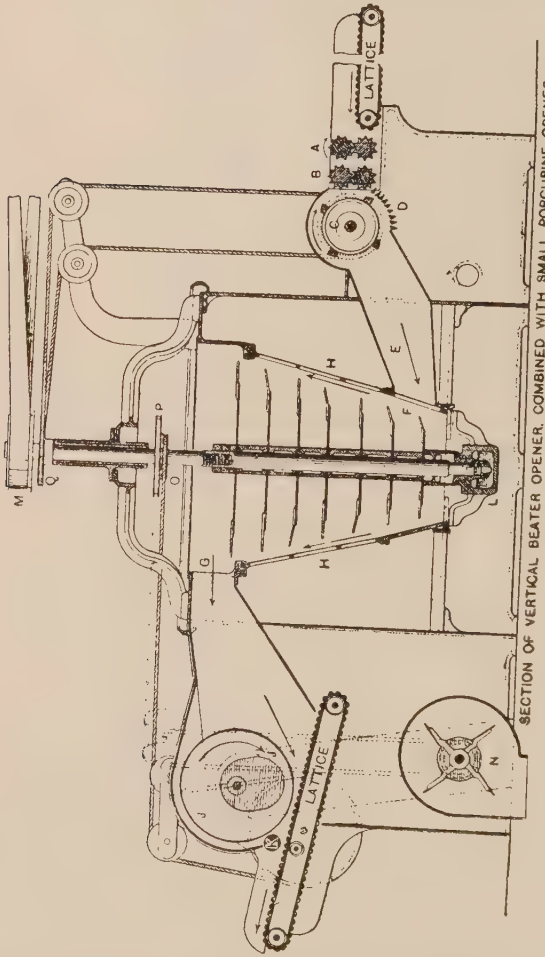
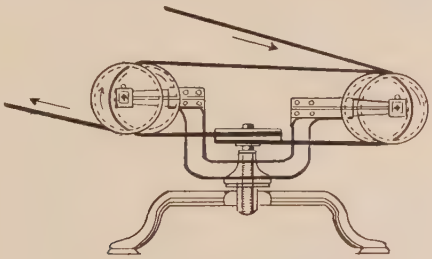


FIG. 5.

or other chief driving shaft. (Sometimes independent motor driving is now adopted for openers, and a 20 to 25 horse motor may serve for a machine containing hopper feeder, large horizontal or vertical cylinder, blade beater, and lap part.) Mark position of floor

apertures underneath the fans, take fan pipes away and carefully cut the holes to size required. The dimensions in one case are 18 inches deep × 23 × 14½ inches, or an inch greater all round than the aperture in fan-box casing. Sometimes the fan hole has been cut previously and rules position of machine. After attaching fan pipes firmly to frame sides, the other three opener sides may be connected to the opener-end side, everything should be correctly levelled and made parallel, and opener portion fastened to scutcher end. In putting in the fan shafts and fans, see that each fan is very firmly fastened in position; the present writer has known openers and scutchers to give much trouble until it was found that fans were loose or slack on the shafts. Also it is better to have the face of each fan blade turning in the direction of the flue outlet (Ample flue dimensions from fan hole to dust chamber, and arrangements which prevent one flue or fan from affecting another are very advisable. Numerous cases have occurred in which a



ARRANGEMENT OF DRIVING BY ROPE ¾ IN DIAM.

Fig. 6.

defectively working opener or scutcher has been converted into a really good one by simply giving better facilities in directions specified. A sufficiently large dust chamber and freedom from back draught are also important.)

Each fan may have a separate flue to the dust chamber, the flue being possibly 30 × 24 inches, and bends in flue pipes should either be very rounded and gradual or else entirely omitted.

By all means make the fan boxes airtight—probably by wooden casings or boxes, cemented at top and at all jointings.

Fans being quite finished with, let the whole framing be relevelled.

The three-legged vertical cylinder bearing may now be put in position, being fixed by steady-pins, take out and clean the steel discs and footsteps, and place the bottom footstep under the bearer.

Bolt the corrugated dish on the three-legged beater, and also the tin feed pipe to the inlet opening of the opener side, setting the opening in the dish to the tin feed pipe and locking in position to

three-legged bearer. Fix large top dish in position and bolt to the feet on frame sides. Place vertical cylinder shaft in position and thread on the bottom discs with blades, following by a cast-iron washer and then by cylinder arms from mark 1 to 14, with figures upwards. Lock with two washers and lock nuts. Four-legged bearer now in position on top dish; fasten up firmly and secure the top cast-iron bush to the bearer. The cylinder must of course revolve freely. Next affix the grids around the cylinder, starting with No. 1 at the inlet hole and going round in direction of cylinder rotation. Numbers on top dish to agree with those on grids. Apply steel band to bottom of grids and make secure. Top position of grid may be fastened by unscrewing grid set screws for their heads to bind against the heads of the outside rim of top dish.

Attend now to the cages; put on cage bends, place the door underneath cage dust bars and put in the cages. Also inside

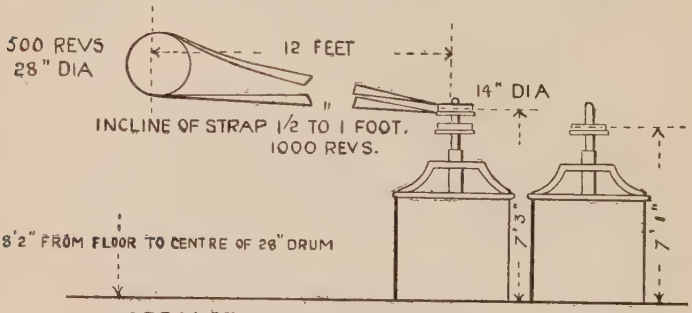


Fig. 7.—Contrast rope and belt-driving for the vertical opener.

dampers if such are used, the edges of such dampers which face the cotton being in advance of a vertical line drawn through the cage centres.

Edge of bottom guide plate to set as close to bottom cage as possible without touching. All parts of lap end will now go readily in position. Now place beater bars in position. There are marks for the exact position of feed rollers. The pedal shaft is put in position followed by the pedals.

(From path of beater blade approximate settings to pedal nose are $\frac{7}{16}$ inch for Sea Islands and Egyptian cotton, $\frac{3}{8}$ inch for American, and $\frac{1}{4}$ inch for Indian. Beater bars about $\frac{1}{2}$ inch from path of beater.)

Bolt bottom part of exhaust for casing to opener side, noting the steady pins and put exhaust fan in place, setting clear of casing. Apply top fan casings, connect the tin pipe from top dish outlet to opening in exhaust fan casing, and set the damper in exhaust fan

casing as far in as possible; then put on cover plate and large hinged cover.

Full-lap stop-motion parts and any other details may now be erected and set. Wood packings round the framing to make air-tight.

A Crighton opener is usually directly preceded by a porcupine feed, which in its turn may be preceded by a hopper feeder. The porcupine feed leaves the machine shop so complete that erection is simple.

It must be accurately levelled up and coupled to the mouth-piece and dust trunks which connect the vertical opener to the porcupine opener. Usual gaiting-up precautions of cleaning, oiling, screwing up, testing without cotton—especially beaters and fans. Piano motion to be accurately adjusted. Lattices got to run centrally and freely. If the cotton does not feed upon the dust cages equally, the fan may be set a little farther away from the inside casing on that side which is delivering the most cotton. Cage-end dampers may be re-adjusted for similar effects.

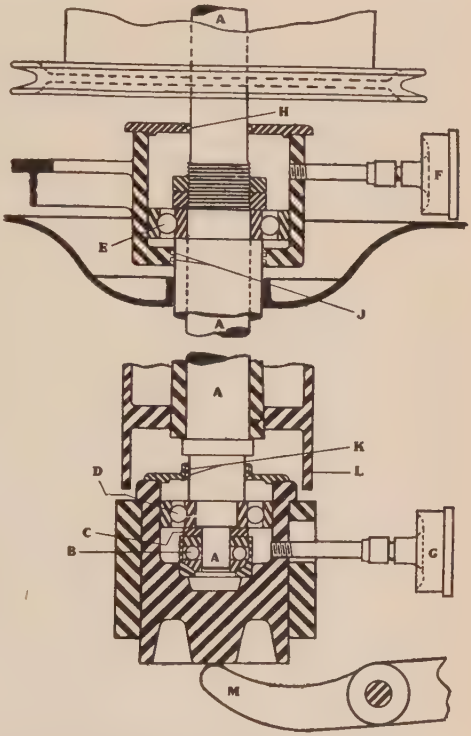


FIG. 8.—Messrs. Tweedale's and Smalley's.

Mixing and distributing lattices revolve slowly, and are perhaps best driven by wheel gearing after the first rope drive from the bale breaker.

For Indian cotton there are sometimes two Crighton openers combined in the one machine.

For American cotton and moderate Egyptian one Crighton is considered sufficient.

For Sea Islands cotton it is not in favour at all.

Crighton Footstep.

There has always been trouble with the footsteps of the heavy vertical conical beaters.

The illustrations show important efforts by good firms to obtain good conditions by means of surrounding the footsteps by oil and water chambers, the liquids renewable by piping from outside the machine.

Also in Fig. 8 at M it is shown how to adjust the distance between the vertical beater and its surrounding grid.

There are many who consider this footstep to be one of the most likely positions to get maximum benefit from ball bearings, even to the extent of simplification in regard to the liquid chambers.

The heavy character of this vertical beater, the weight on the footstep, the proximity to loose dirt and fibre, and the tendency of such matter to drop to the floor, have always affected this consideration. Fig. 8 shows ball bearings.

Erection of Scutcher.

In a set of machines each may have a special letter as X, Y, Z.

In any one scutcher standing at the feed end facing the machine, all parts may have the odd numbers, and on the right-hand side all parts the even numbers as X1, X3 upwards, or X2, X4 upwards.

Usually, important brackets and parts are steady-pinned to position—a very great help in erection.

Cotton machines are usually well marked and well arranged for their own position ; the present writer has erected or helped to erect almost every machine in spinning, doubling, and weaving mills and can testify to the efficiency of cotton machine makers in this respect.

The position of the fan hole, as marked on the plan, or as previously made, helps to decide and rule the exact position of the scutcher, and presumably the fan-hole position will not have been fixed without all due consideration, of all attendant circumstances and details.

All parts to be thoroughly cleaned and details assembled in as convenient a position and in as good order as possible.

To begin with, place the sides of the scutcher loosely in position, and connect opposite sides by any stretchers or cross-bars.

After fixing the first parts of fan pipes loosely to the framing, adjust the fan box exactly to the aperture in the floor.

Carefully fix the beater pedestals to their marked positions on the framing, lift the beater in position even if it be afterwards lifted out for any purpose. The beater is the ruling factor in getting the machine square for proper driving, and the framing may need some slight adjustment to get the beater quite parallel to the line shaft, counter shaft, or motor shaft—according to kind of driving.

If the beater shaft is not parallel to the driving shaft the main belt will not keep properly in its position. Other shafts, such as

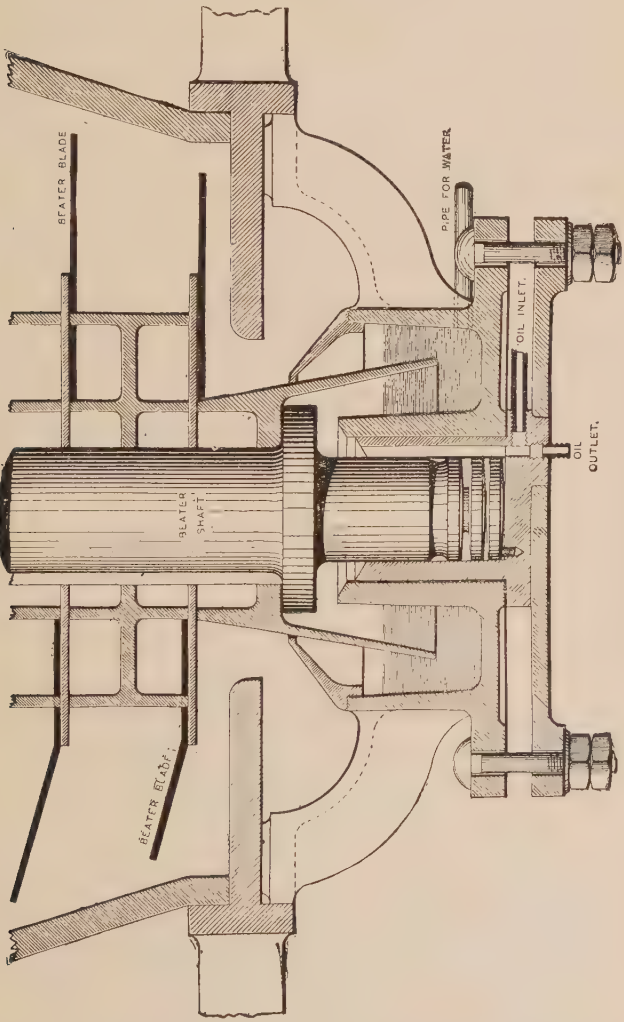


FIG. 9.—(Messrs. Hetherington).

fan shaft and slow-motion shaft, will usually come to with the beater from which they are driven.

At this time also the framing must be set level with the spirit level, suitable wood packings being used under the framing. Often wooden wedges are used for all preliminary levellings for this and other machines, to be replaced by permanent wood packings when ready and convenient.

If the fan hole has not previously been made it may now be carefully cut out, and the fan and all fixings placed as described elsewhere.

Framing to be again tested for level, and any floor or other fastenings made that are deemed necessary. Be sure to make the casings around the fan and fan hole properly airtight.

23 × 14½ × 18 inches deep have been given as dimensions in one case.

The fan shaft and fan having been fully attended to, we may now fix up the fly door beneath the leaf bars and follow up with the cage bends and bearings, the cages themselves, and cage dampers, if same are used.

Put up the lap end, including cage delivery rollers, calendar rollers, fluted lap rollers, and lap cradle, connected gearing and brake motion.

Let beater bars and leaf bars be now applied and adjusted if not already done.

The knife edge over beater may be set just nicely clear of beater path to prevent cotton from stringing or following round with the beater.

The plate leading up to bottom cage should just be clear from this cage. Fig. 9 indicates still other features of the Crighton Footstep.

Settings and Workings.

Feed roller stands placed to position marks on framing. Noses of pedals to be distant from beater path ¼ inch for Indian, $\frac{5}{16}$ or $\frac{3}{8}$ inch for American, $\frac{7}{16}$ for Egyptian, and possibly ½ inch for Sea Islands, although Sea Islands and long Egyptian cotton usually have an extra pair of feed rollers coming next to beater path and do not strike cotton over the pedal noses.

The extra feed rollers give more time for the piano regulator to level the cotton feed and reduce danger of injury to cotton fibre.

The pedals having been placed in position, the other parts of the piano feed regulator may be attended to, differing somewhat in detail accordingly as to whether it be a bowl box, tripod, or link regulator, but in each case quite straightforward.

(*a*) Set the regulator parts so that the cone belt will be near the centre of length of cones, when there the pedal noses are depressed to the known extent given by the average thickness of cotton—a piece of actual lap thickness or equivalent gauge being

used. Sometimes the cone belt is preferably left a little away from this middle position and leaning towards the thicker part of driven cone, so that it is perhaps better ready for meeting the case of an empty lap and three laps working instead of four for the moment.

(*b*) If bowls are still used fill them in bowl box so that the closed end will be filled first.

(*c*) Set the worm on end of cone drum to gear as deeply as possible with the worm wheel.

(*d*) Make the scutcher framing as airtight as possible at bottom and elsewhere.

(*e*) Have the vertical lap racks acting equally on both ends of lap roller.

(*f*) Set the knock-off motion to give correct length of lap or apply the correct change wheel for this.

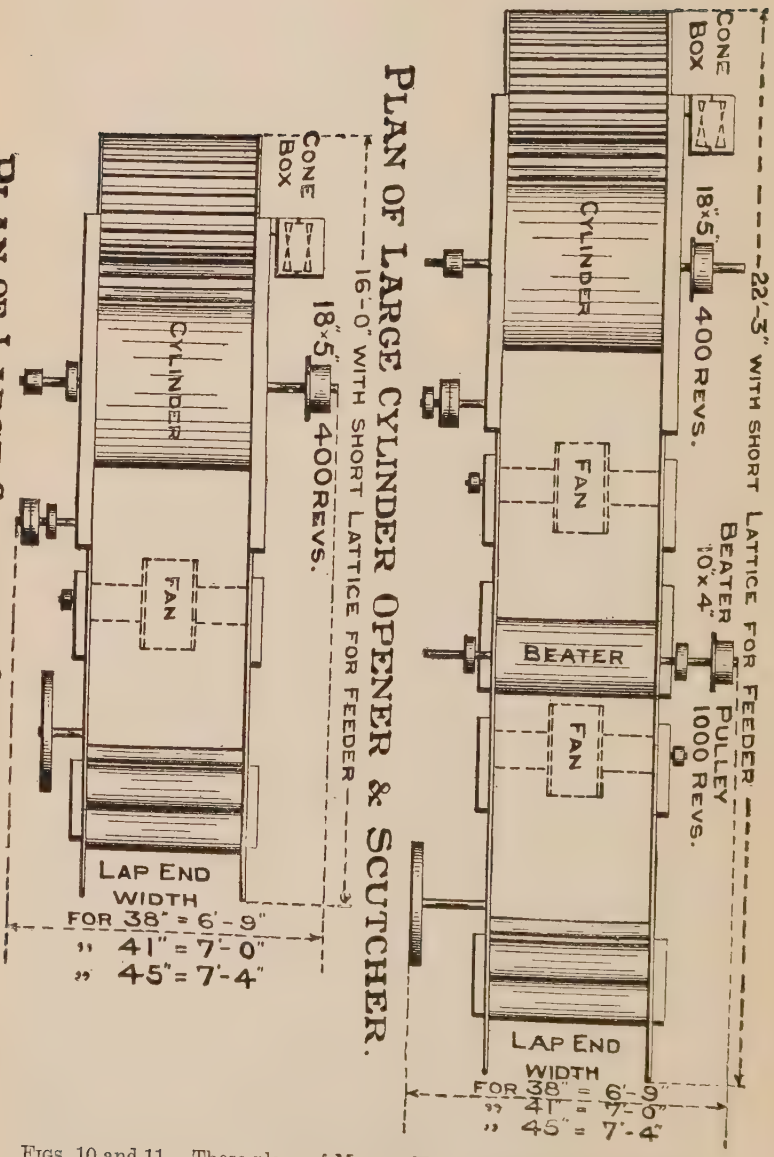
In regard to a general re-setting or repair of an opener or scutcher there is much less need for this than on cards, combers, fly-frames, or mules, especially if the machine is kept in reasonable working condition. Lap end taken down and thoroughly cleaned every few weeks. All necks and bearings regularly kept free from fluff and dirt.

Cone belt of the best kind procurable and kept narrow. Piano motion well cared for and adjusted properly. Ropes and belts all in good condition. Measuring motion acting promptly. Uniform and effective action from the brake. Beater bars and inside of machine clean and smooth.

To make heavier laps per yard we may thicken the feed per yard or speed up the feed end through the cone drums. To make longer laps alter the proper change wheel.

Specification for New Machines.

For Indian, low American, and Brazilian cottons either a Crighton or a Buckley opener may be used followed by two single scutchers each with one beater. For good American and Egyptian any good horizontal opener followed by one single scutcher. All scutcher beaters with three blades. Always four calender rollers at lap ends. Laps to be made $\frac{1}{2}$ inch wider than width of card on wire. Scutcher creels for four laps. Piano regulators of the link type without bowl box. Blade beater to strike the cotton over the pedal nose for Indian and American cotton, but from an extra pair of feed-rollers for Egyptian or Sea Islands. Laps of 40 to 45 yards long and of weight per yard equal to 11 oz. for 60's to 100's, $11\frac{1}{2}$ oz. for 50's, 12 oz. for 40's, $12\frac{1}{2}$ oz. for 30's, 13 oz. for 24's to 30's, 14 or 15 oz. for 10's to 16's. Counter shaft attached to scutcher only when inconvenient to fix to ceiling on account of possible vibration. 4 to $4\frac{1}{2}$ inch main belt and counter shaft about 400 to 430 r.p.m. Three-blade beater to make about 850 r.p.m. for Egyptian, 950 for



FIGS. 10 and 11.—These plans of Messrs. Hetherington indicate machine dimensions in an educational manner.

American, 1000 for Indian. Two-blade beater 200 to 250 r.p.m. more quickly.

Scutcher Speeds.

The chief and central revolving body on a scutcher is the beater, which receives motion directly from line or counter shaft, and distributes movement to all other parts of the machine. For a double-blade beater the revolutions may be about 950 to 1,050 for Egyptian cotton, and 1,100 to 1,200 for American. For a three-blade beater the speeds are reduced below the above by possibly 150 to 200 revolutions per minute. The fan is usually the quickest revolving part of the scutcher, and may have possibly 1,300 or 1,400 revolutions per minute, obtained directly by belt from the beater, and not varying much for the two cottons. Also driven directly from the beater we have the slow-motion pulleys making possibly 300 to 350 revolutions per minute, and controlling the speeds of practically all the feed and delivery parts. Speaking in a general way these parts may revolve somewhat more quickly for American than for Egyptian cotton, because of usually greater production required and higher beater speeds in use; this applying almost more to the feed than to the delivery parts, because of greater weight per yard of scutcher lap for the shorter cotton. Approximate speeds of other parts may be 10 to 14 revolutions per minute for the fluted lap delivery rollers, 950 for bottom-cone drum, 760 for top-cone drum, 9 to 14 for feed rollers, 11 or 12 for bottom calender, 15 second calender from bottom, with rather slower speeds for the higher calenders, 3 to 4 for the cages, 23 or 24 for the cage-stripping rollers.

Safety first on Scutcher.

One device may be briefly described as follows: A slotted plate or flange is secured to the beater shaft and rotates therewith. A spring lock is fastened to the framing, and a part of this locking arrangement acts on a projection on the beater cover while the beater is working. The beater must be stopped before the locking finger can be drawn from the cover and passed into one of the slots in the revolving plate. The same operation that releases the beater cover locks the beater itself, and a distinctive feature of this arrangement is that the dropping of the cover automatically locks the cover down and releases the beater.

By way of emphasising the need for such devices, the proprietors of this particular one give the following detailed list of accidents, taken from the records of the Department at the State House in Boston:—

1. Opened door of picker, or scutcher, to remove some waste,

when left hand was struck by beater, causing loss of one finger above second joint.

2. Crawled under machine, and put his hand into the beater. Right hand taken off near shoulder.

3. Left hand injured by being caught in a beater of a lap machine.

4. Lost right arm in raising cover of beater chamber and putting right arm in.

5. Lost right arm by raising cover of beater to remove some cotton.

6. Lost left hand by raising cover to beater to free rolls which had become clogged.

7. Lacerated one finger by putting his hand in beater.

8. Put his right hand in beater cage before machine had stopped, and lost thumb and first finger.

9. Left thumb was struck by a revolving beater on opener machine.

10. Was trying to clean some waste out of picker (scutcher) when right thumb was caught by beater and injured, requiring amputation.

The writer may just add that a beater revolves so quickly that it can scarcely be seen when at full speed. This we have frequently tested by running a blade beater with the cover up, taking care to have no one within danger.

Emergency Safety Stop-Motion.

At a Bolton mill the writer examined a special safety motion applied to an opener with the object of preventing an accident, or at least greatly minimising the seriousness of the accident, supposing an operative were to get fast at the front or delivery of the machine. This is not a patented motion that we are aware of, and it was simply applied because one of the operatives happened to get her hand and arm taken in with the lap roller in starting a new lap, and after the brake had been put on. A similar accident has often occurred at one place or another in times past.

In the appliance under discussion a board runs along the front of the machine not far from the floor and underneath the position of a full lap when the latter is resting in the cradle ready for taking away. The cradle for the full lap consists of two curved stands—one for each end of the lap, and does not run the full width of the machine.

Suppose an operative were in danger of an accident he or she could not fail to push down the pivoted full width board, and the connections are such that the brake is released, and the spring that is in the vertical racks would nicely ease the operative's hand or

arm. This would be something of itself, but might not be considered sufficient, even if it were also coupled to the full-lap knock-off motion.

The lever connections of the safety board are further extended so as to link up to the slow-motion driving belt. Supposing the safety board were to be depressed, then the slow-motion belt would be also promptly placed on the loose pulley, thus stopping all the delivery or front part of the machine. The necessary latching of the motion and the necessary spring or weight connections are neatly carried out.

Safeguard in Starting a New Lap.

The foregoing is a description of an emergency safety motion which is not applied as largely as it might be with advantage.

In the ordinary way of working a careful attendant will probably be sure to have the leading end of a fresh lap passing properly round the lap roller before dropping the vertical racks and releasing the brake. In this connection it may just be mentioned that there are devices for aiding in wrapping the cotton round the smooth lap roller at the start, so as to obviate or minimise the chance of an operative's fingers getting fast. For some reason or another, however, such devices do not appear to have met with much adoption. It is possible that such a device may be considered somewhat in the way of the operatives—a by no means uncommon thing with covers and guards in various positions of a cotton-spinning mill.

Opener Beaters.

On the whole, accidents appear to be less numerous in connection with opener beaters than scutcher beaters for one reason or another. The large circumference of a cylindrical porcupine beater, for example, permits of the casing being made more effective between beater and cages, than is the case with many scutchers. Also, it is not the usual practice to apply a hinged door or top cover to the large beater, as on a scutcher, and this is naturally a great safeguard against accidents. The more usual practice is to extend strong top bars over the top of the beater and to firmly bolt these cross-bars down to the side framing. So that it is a distinct trouble to take off a cross-bar. In the Buckley opener it is well known that these top cross-bars are fitted with strong nogs or spikes on the inside or underside next to the beater, in order to aid in the opening of the cotton.

As a further step towards preventing accidents in the blow-room, the writer has recently witnessed an instalment of iron cross-beams over the blowing-room machinery, fitted with a strong sliding carriage, which can be readily pushed to any position. A

pulley block is hooked to this carriage and any one of the beaters, and, also we believe, the calenders can be easily lifted up or down by one attendant, with the minimum of trouble and danger. For the periodical taking out of calenders to give a thorough cleansing or even for taking out beaters occasionally this should be of great service.

Perhaps the most applied motions for lap fronts consist of cage guards which may rise and fall with the lap rack and which permit full inspection of laps.

An objection urged against such guards has been the difficulty of picking out bits of jute or other foreign material from the lap during its formation.

Lap Guard and Lap Threader.

Lap guards are now very largely applied.

In a recent device the functions of lap guard and lap-end threader are combined. The open-work or lattice-work guards now in use at any rate allow of people concerned noting the condition of the work, although more or less in the way of picking leaf or other defects from the lap. Lap threading by hand has certainly resulted in bad trapping of fingers when an attendant drops the weight *before* threading the lap end, instead of *after*.

The author is in regular contact with a man who lost a finger end years ago owing to an accident of this kind.

In the arrangement under notice the lap guard is a hollow structure which may be composed of thin metal strips or leather, screwed to three curved or half-moon supports or stays, and adjustably set screwed or bolted to a shaft passing across the front top of the opener or scutcher.

Also set screwed to one end of this guard shaft is a lever having a movable weight, adjusted to over-balance the weight of the guard and so tend always towards lifting the guard. The upward movement of the guard is restrained to agree with the increasing diameter of lap.

Upon the top of the anti-friction rack is secured a small bracket carrying an anti-friction bowl, and which runs on the top edge of a lever also secured to the long guard shaft.

The arrangement is such that the increasing diameter of lap is accompanied by the slow rotation of the guard shaft due to weight pull so that the guard always lifts just in advance of the cotton lap.

The bottom bar or cross-bar of this "mills" arrangement consists of a board used as an automatic lap threader. For a new lap the guard is let down until one of its connections impinges against a fixed stop on the framing, and the board is then almost touching the fluted shell roller, and at a controlled distance from the lap roller.

As the front end of the cotton for the next lap comes under the lap roller, it is operated upon by the board so that the cotton coils naturally round the lap roller without touching by hand.

A special starting handle is used to re-start the feed and delivery of cotton, instead of using the ordinary drop motion handle, the alteration being required to work the combined lap threader and lap guard to the best advantage.

The pulling forward of the new starting handle drops the lap guard into position, unlatches the drop lever, and threads the lap end round the lap roller.

The lap threader can be brought down before the rack is lowered if required.

When the lap is full the guard is raised into its top position to permit removal of full lap.

Lap-Threading Device.

It is well known that the cotton often fails to come properly between the lowest and next to the lowest calender rollers upon an opener or scutcher when a machine is started after being fully stopped, including the beaters and fans.

The manner of this happening may be explained as follows: An opener, or scutcher, may be said to have usually three distinct starting and stopping motions, each one producing a different effect from the other two. First of all there is the main driving belt, which is placed upon the loose pulley by a chain and screw arrangement, or equivalent device, when the whole of the machine is required to be stopped.

Then we have the slow-motion driving arrangement, which includes usually a fast and loose pulley and a driving belt, by means of which all the more slowly revolving parts of the machine and also the cone drums are driven, the slow-motion belt being driven from a pulley on the end of the beater shaft.

The parts driven by this belt include usually all the calenders, cages, fluted lap rollers, feed rollers, feed lattice and cone drums, but not the heavily running and quickly revolving beaters and fans. It frequently happens that the slow-motion belt is placed on its loose pulley, thus stopping all parts excepting the beaters and fans.

The third stopping motion is that more particularly connected with automatic knock-off motion for controlling the length of cotton sheet that goes upon each individual full lap. This motion acts as a cut off or stop for some of the parts that are driven by the slow-motion belt. When a sufficient length of cotton has passed upon each lap or roll of cotton, the measuring motion automatically stops the calenders, cages, feed rollers and feed

lattice. The fluted lap rollers at the delivery are permitted to revolve so as to neatly break off the lap sheet ready for doffing, while it would be foolish to stop the high speed beaters and fans on account of the momentum which these parts acquire, and the time and power which would be absorbed in starting and stopping such heavy running parts for every full lap. We will assume a scutcher to be fully stopped, and all three of the stop motions to be putting its parts out of action.

Start first the main belt, then the slow-motion belt, and finally gear up the parts connected with the full-lap stop-motion.

Sometimes the cone belt slips or something else happens to stop the feed and delivery of cotton when the machine is started. Sometimes the operative spits on the calenders or rubs with soap to get the cotton lapping round properly. In many cases the attendant will creep beneath the lap rollers and fluted lap roller and will guide the cotton in its proper path by hand. This is not a very nice operation, and is not entirely free from danger, so that there is more or less objection to all of the foregoing three methods of getting the cotton to first pass between the third and fourth rollers. Once properly started, the cotton naturally keeps passing forward properly until there is again some such happening as we have above described.

Herein we have the reason for the introduction of the lap-threading device previously referred to, and which may be briefly described as follows: Behind the four calender rollers a narrow swing door is stretched across the width of the machine just about on a level with the centre of the bottom calender. Ordinarily, when the machine is in action, this swing door is of no service whatever, but assuming the initial end of the cotton sheet to be passing through the calenders after a complete breakage, the door is just held against the bottom calender, and will not permit the leading end of the cotton to go anywhere except in its proper direction between the third and fourth calenders, counting from the top.

Although only required occasionally, such a device is so very cheap and simple that wherever there is suitable space behind the calenders either this or some equivalent device ought to be worth adopting, and a factory inspector might reasonably ask for this.

It occasionally happens that quite a nasty accumulation of cotton may pass below the bottom calender before the through connection is made, and such cotton fastens itself round the cross-shafts until considerable effort is required to loosen it.

The lap-threading device is one of the lesser known details of an opener or scutcher, and constitutes one of several devices more or less used to secure the safety of the operatives.

Horizontal Exhaust Opener.

No. 2 Model (Dobson & Barlow).

The machine is provided with a lap part and two sets of cages with a dust fan to each set running at 1,350 r.p.m.

The beater is 18 inches diameter and is made with two or three blades. The blades are planed on both edges, so that the beater can be reversed when one edge is worn.

Bars hitherto used have occupied a small area for cleaning purposes, and the dirt produced from actual tests is not great. The feed part of this machine has been redesigned and, as now arranged, is simply a conveying machine, and the object of this new system is to obtain the combination of both cleaning and conveying of the cotton.

The firm have reconstructed all the cylinder or feed end of the machine, and have adopted a porcupine cylinder all the width of the machine with the patent cleaning bars, which will give very much more cleaning area than has been possible before. The cotton is drawn by means of two fans, each having six blades and calculated to produce

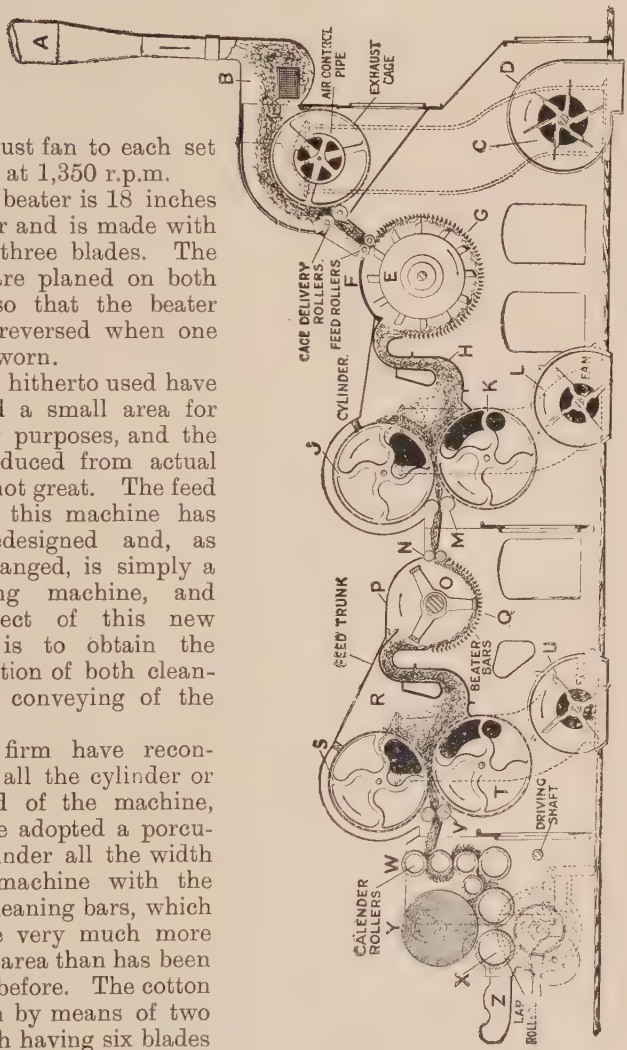


FIG. 12.

a velocity of 5,000 feet per minute. The air current from these fans works in conjunction with an inner tube or air-control pipe, placed inside the cage receiving the cotton. This pipe has an opening on the top which controls the air the full width of the machine, thus causing an equal draught across the same, by which method the cotton is distributed on the cage in question.

The control pipe is stationary, but can be regulated so as to draw the cotton at any given point on the top half of the cage.

The firm claim over the former makes of horizontal exhaust opener greatly increased cleaning power, through having about seven times more area of cleaning bars. The narrow central beater on same shaft as two fans is dispensed with.

Through the introduction of the inner tube or air-control pipe they claim a positive even draught across the cage, the aperture in the top of the pipe being so shaped as to draw the cotton from an average round pipe and distribute the same over a cage of 38 inches to 45 inches in width.

Blow-Room for 60,000 *lb.* 50's *Good American.*

We will assume we are intending to spin a good quality 50's carded yarn average from very good American cotton, and we desire to keep our blowing-room machinery well employed. It might be found a convenient arrangement to use two openers followed by four single scutchers, each opener serving two scutchers, and no intermediate or breaker scutchers being employed. The openers might each contain a large cylindrical or porcupine beater followed by a three-blade scutcher beater, and if any difficulty was experienced in the two openers keeping up with the production they could be run well up to time at the week-end, or we could resort to the somewhat extreme practice of doffing the laps without allowing the machine to stop. We will assume each full scutcher laps to weigh 36 lb., and each yard of lap to weigh 12 oz., and remember that 60,000 lbs. weight of laps is required from the scutchers.

With four scutchers producing a total of 60,000 lb., each scutcher would produce 15,000 lb.

$$15{,}000 \div 36 = 416{\cdot}6 \text{ laps},$$

or, say, 417 laps from each scutcher. It may be added that some firms might prefer to work the machines more easily, and use more of them, say, three openers at 20,000 lb. each per week. For the ordinary American cotton some spinners would use two Crighton openers. For moderate American cotton some spinners would use both breaker and finisher scutcher.

Cards for Foregoing Blow-Room.

We will assume, as in previous statements, that very good American cotton is being used, and the average counts of spun yarn is about 50's carded. Each card may be set out to produce 500 lb. per week of good sliver, and assumed to lose 6 per cent. in waste of one kind or another. With 6 per cent. loss the 60,000 lb. of laps would produce a total weight of sliver as per following calculation :—

100 lb. of laps gives 94 lb. of sliver.
$\therefore$ 100 : 60,000 : : 94 : ?

$$\frac{60000 \times 94}{100} = 56{,}400 \text{ lb. of sliver from cards.}$$

Taking each card at 500 lb. production, we get number of cards as follows :—

56,400 ÷ 500 = $112\frac{4}{5}$ cards, or, say,
113 cards as per calculation.

To this number may be added three or four for stoppages due to stripping, grinding, repair, or other purposes. A 24 inch diameter doffer might make about $11\frac{1}{2}$ revolutions per minute under the conditions specified.

If we feed a 12 oz. lap, and deliver a ·16 hank sliver, and allow 6 per cent. waste loss, hank or counts of lap and the card draft might be obtained from the following calculations :—

Divide the weight of 1 yard of lap reduced to grain into 8·33.

437·5 × 12 = 5280 grains in 12 oz.
8·333 ÷ 5250 = ·00158 counts of lap.
·16 ÷ ·00158 = 101·2.

$$\frac{101{\cdot}2 \times 94}{100} = 95{\cdot}128 \text{ mechanical draft.}$$

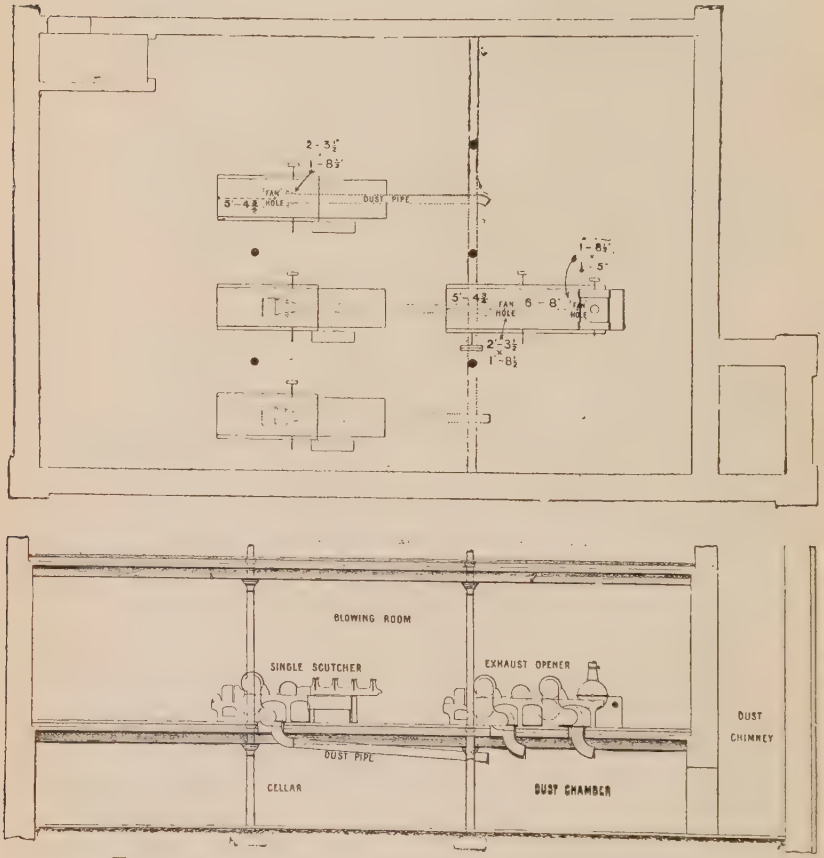
For ordinary American cotton, and spinning 30's to 40's, the assumed production of 500 lb. per card would be too low, and 650 lb. to 700 lb. would be nearer the mark. For rather lower counts many firms obtain 800 lb. or more per card, based on a $55\frac{1}{2}$ hour week, as per above.

Dust Chambers for 80,000 *lb. Weekly of American Cotton.*

We might assume a mule-spinning mill spinning average 30's and 32's twist producing 1 lb. per spindle of yarn per week from American cotton. Three combined openers and scutchers with porcupine and hopper feeders would meet this case, followed by six breaker scutchers, and these latter by six finisher scutchers, thus giving

rather a moderately large blowing-room. Often, the finishers are now omitted.

One of the best systems in practice is to have practically all the space beneath the blowing-room utilised as a dust chamber, that is in regard to the greatest efficiency to obtaining good easy exhausts.



FIGS. 13 and 13A.—Plan and elevation of dust arrangements.

The fans of the exhaust openers and of all the scutchers will blow the dust and air directly into the dust chamber, the exit pipe of each machine pointing directly towards the outlet or chimney and be provided with a light tin door to stop any back draught when the machine is not working. In connection with the dust cellar it is

advisable to provide a dust chimney extending above the highest point of the building to permit the free escape of air while the heavier dirt particles settle down to be afterwards periodically cleaned away. The cellar should be at least the height of a tall man, and the chimney should be capacious.

Figs. 13 and 13A indicate the arrangements for a smaller installation.

American v. *Egyptian Cotton. On Openers.*

Partially due to natural causes, and partly due to the heavier baling pressure which the Egyptian cotton undergoes, it is found that this cotton will pass through an opener or scutcher in a more solid condition than will American. The American cotton with same speeds and adjustments of parts will refuse to give the required weight per yard of lap. There are various methods of getting the more open and bulky American cotton through in sufficient quantities so long as the conditions are properly understood. We may, for example, move the evener roller (or evener lattice, as the case may be) farther away from the spiked-lifting apron; an alternative plan is to reduce the speed of the equaliser so that it will not drive the lumps of cotton back as readily. The speed of the bottom feed lattice may be increased for the American cotton in order to feed the cotton more freely forward to the spiked lattice. In this connection it may be pointed out that the filling motion for the feed box of a hopper is usually based on the true principle of absolutely depending upon weight and not bulk of cotton. For example, in several examples the weight of the cotton in the feed box presses a swing door backwards, and in this way stops the feed when required.

It has been also found that the very best results are obtained in the spiked-lifting aprons of hopper bale breakers and hopper feeders by adapting the size and angle of spikes somewhat to the nature of the cotton to be used. It by no means follows that what is best for Egyptian is also best for American.

The second feature we notice is also directly connected to this question of regulation by bulk instead of weight. Suppose, now, we change from loosely packed American to hard pressed Egyptian, and make no alterations at the opener or scutcher. It is highly probable we should now have the laps coming out altogether too heavy, and possibly also too great in diameter, an explanation for this being now discussed. We will assume the piano feed regulator and other parts permit the same bulk of Egyptian cotton to reach the cylinder or beater as there was of American. There will be more weight of the Egyptian, and this will be opened out by the cylinder to have greater bulk at this point than there would have been of American, and it is now too late to regulate the same. The

net result will be delivered laps that are both too heavy and too bulky, whether the full laps or short lengths be compared. A consideration of the two examples we have just explained will probably help to clear the air for some of our readers in regard to various unexpected results when changing from one kind of cotton to another, in which there are different degrees of density, whether such alterations be of the extreme character quoted in our two examples, or are of very much milder character.

Changing from American to Indian Cotton.

Starting with the hopper feeder. It is possible the evener would have to be set closer to the elevator, or else the evener run so as to prevent too much of the more solid Indian cotton from passing assuming no change in counts of work were made. If we are also going on coarser work we should probably make a heavier lap per yard. In order to get sufficient cleaning it is probable we might find it profitable to run the cylinders and beaters of opener and scutchers somewhat more quickly. In the same way at the card it would depend on counts of work as to extent of alterations. Extra efforts would be necessary to get the cotton sufficiently clean if anything like the same kind of work were expected, and in such an event we might possibly run the flats a little faster, strip a time oftener, and in other ways endeavour to extract the extra dirt from the Indian cotton. When we came to the draw frames and fly-frames it would be a question of whether we could manage well enough with the existing rollers, since we might find it awkward to set the centres of rollers near enough for the shorter Indian fibres. Changing the rollers is such an expensive affair that we might try to manage without doing so, although roller laps and somewhat uneven drawing might be the result. It might be awkward to set the beater and feed rollers as near as required for the Indian cotton. Briefly, the chief difficulties would be found in obtaining the extra cleaning required for the more dirty Indian cotton, in being able to set certain of the parts sufficiently close, and in keeping the counts of work sufficiently uniform with the fresh cotton.

We should be fortunate if there were not trouble with both work and work-hands at the fly-frames owing to extra breakages of threads. If the counts of yarn were also altered then it would be difficult to get the exact counts at each succeeding process.

The Youlten Opener.

Many attempts have been made to introduce methods of preliminary opening and cleaning of cotton differing from long-established methods. The hopper bale opener and hopper feeder have proved far and away the most commercially successful methods of such opening without using any of the ordinary forms

of porcupine cylinder or blade beater, and indeed have themselves become essential parts of the established methods and equipments. They depend for their opening results upon the principles of tumbling the cotton about and giving a rough kind of combing treatment. The hopper feeder, indeed, produces a sufficiently level sheet of cotton to justify its being made directly into a lap if any good purpose would be served thereby, although we have not heard of this being done, and if it ever were done it would only be as a preliminary for feeding a number of laps to the opener instead of a single lap sheet as at present.

About 1913 the Youlten opener attracted attention in this country, and differs in its construction and action from the established methods.

On 23rd March, 1922, Mr. Basil Youlten, son of the inventor, lectured on this opener before the members of the managers' and overlookers' class at Bolton Technical School.

A full-sized working model of the essential central feature or opener itself was on view to illustrate the lecture. A few machines were working in 1913; progress was held up by the war, but the invention is again well on its way, and is just now being made by an eminent firm of cotton machinists.

Apparently the central feature consists of a screw-like beater built up by a very large number of individual steel fingers on a 3-inch shaft to a diameter of possibly 15 inches or so. This opener differs from all others known to the writer. The cotton enters the opener chamber and drops into the range of opener action. Making 2,000 or more r.p.m. the beater drives the cotton upwards, and the latter is removed by the air current when sufficiently opened and lightened.

The heavier impurities may be removed by fan from the bottom of the chamber. Fine dust is released very effectively and either goes out at the bottom, or if it goes with the opened cotton may afterwards pass through cages in the usual manner. The essential Youlten opener is pieced up to feeding and delivering mechanism as required, the complete machine sketched on the board showing a bale breaker, the Youlten opener, a hopper feeder, and a single scutcher with a blade beater and lap-making attachment, all pieced together and taken progressively as shown above. Clearly all sorts of combinations could be made according to opinions and requirements if the central Youlten patent itself does all that is hoped for it—a matter yet to be proved.

The Youlten opener or rotor of apparently about 15 inches diameter revolves inside a cage cylinder of about 40 inches diameter which itself has a very slow rotation, so as to bring all its apertures in turn to the bottom, at which they are operated upon by a slowly revolving externally placed cleaning brush.

The feeding at one end of the rotor or opener, feeding and delivering of cotton both at the top of the rotor chamber, the screw-like action of the rotor or opener, which has one-half of its screw left hand, with the other half right hand—these are distinctive features.

The rotor may be set with its blade points from $\frac{7}{8}$ inch to $1\frac{3}{8}$ inch or so from the cage bottom, the longer fibre requiring the wider setting. Mr. Youlten explained that hitherto the opener had not been really tested for Egyptian or other long staple cotton.

Possibilities of good cotton going with the dirt, of some cotton going forward insufficiently opened, of some dirt drawn with the good cotton, of uniformity in the laps, productions of different classes of cotton, and other features, are all under investigation at the present moment. Productions are supposed to be much the same as for well-known types of opener.

Briefly there is a quickly running beater composed of a large number of double arms, stamped out of sheet metal and threaded spirally on a shaft having a kind of resemblance to a conveyer screw, made with arms set closely together and having serrated rounded tips on its outer edge.

Left hand screw effect for half the length and right hand for the other half.

This special beater revolves inside the perforated horizontal drum, occupying the lower portion thereof, so that the upper portion and side spaces of the drum are air spaces.

Cotton may be fed into the end of the drum so as to be immediately acted upon by the beater, the opened and cleaned cotton being delivered at the opposite end.

There is a pipe reaching through the feed end of the drum and into the upper air space, and a fan blows an air current through this pipe in order to blow the cleaned cotton into the outlet pipe.

A revolving brush acting on the outside of the slowly revolving perforated drum so as to clean off the impurities and keep the spaces open.

The rapidly revolving beater throws the cotton against the inner surface of cage drum. The opening action consists of rapid but not harmful blows on the cotton while the latter is in a loose free condition but confined to a closed space.

Three Special Devices.

A. In Fig. 14 at A is shown the "Tandem" grip designed to give the close fibre bite of the pedal nose, with the better lap regulation more usually obtained from using an extra pair feed rollers.

One lever is placed inside another.

The shell or outer lever controls the regulator promptly.

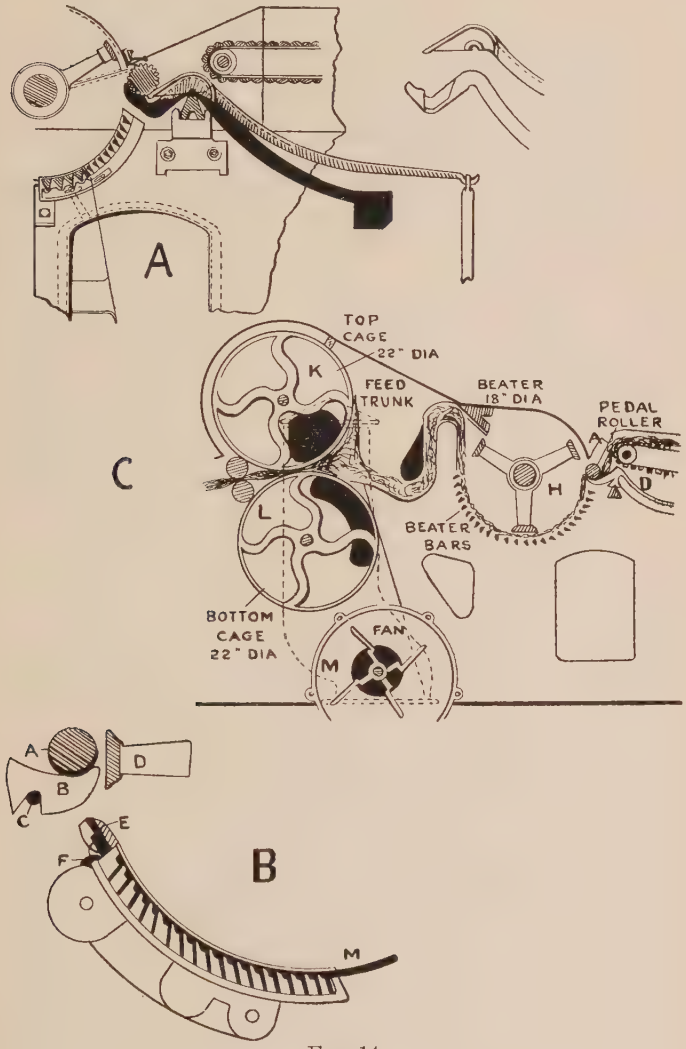


Fig. 14.

The inside lever gives the close grip.

At C, in the centre, attention is directed to the three following features :—

1. The "Swan-neck" feed trunk which gives beater bars under *all* the lower half of the beater.

2. The air current adjustments at the ends of cages K, L.

3. The extended beater bars.

At B. The Shellibaum beater bars in which an increased number of thin steel bars are used instead of a less number of cast-iron thicker bars. Also the bar section prevents the return of any impurities into the cotton under the influence of the air current.

There is a comb-bar at E.

A = the pedal roller and D the pedal.

Sea Islands Cotton in Blow-Room.

One authority has made the following statement respecting Sea Islands cotton :—

"In this class of cotton the preliminary treatment must necessarily be very mild, on account of the length and fineness of the staple.

"In mixing, the cotton should be taken from the bales, broken up by hand, and then thrown upon the mixing. Sea Islands cotton should not pass through any kind of bale breaker. The next process is to rake the mixing vertically down the side so as to get a proper blending of the different marks, and spread it evenly upon the feed table of the opener.

"The type of opener lap machine to be used for this cotton is of a similar construction to an ordinary scutcher with the addition of a cylinder placed between the feed rollers and the beater, the feeder being prepared for spreading loose cotton and also for doubling four laps.

"Better results have been obtained by careful hand spreading of Sea Islands cotton than by using a hopper feeder.

"The feed rollers of the regulator are three in number, viz. the regulating roller and two breaker rollers. The picker cylinder takes the cotton from the breaker rollers and draws it over the grid bars, which are placed below to the beater; the beater takes the cotton from the picker cylinder and throws it up to the cages in an even fleece. The cotton is not subjected to any rough treatment as it would be if the beater were placed next to the feed rollers.

"Weekly production 4,000 lb. if the cotton is taken twice through machine, 8,000 lb. for once through."

The author may add to the foregoing that opinions differ somewhat as to exact opening treatment which is deemed best for Sea Islands cotton. Much of the best Sea Islands is bagged and not subjected to any power press, and this factor diminishes need for a bale breaker.

At some firms for the best Sea Islands the treatment considered

best is to use an ordinary single porcupine opener cylinder of about 41 inches diameter with pedal rollers and extra feed rollers.

For the lower classes of Sea Islands some experienced fine spinners in England will follow this up with a single scutcher having a three-blade beater, but for the better sorts the cotton may go directly from opener to carding engine. In yet other cases the Sea Islands is put through two single openers with 41-inch cylinders, the second opener fed with laps and no blade beater being used at all. The Crighton opener is seldom if ever used for Sea Islands cotton, and not much for the best classes of Egyptian, being considered too severe in its treatment for these longest and finest cottons.

It is, however, now often used for the more moderate and less clean classes of Egyptian, and is of course a great favourite for ordinary American cotton and for Indian. Many mills now have large combination hopper, opener, and scutcher machines, and have the cotton trunks arranged with dampers and valves so that they may use the Crighton or shut it out of action just as desired.

One of the objections to the large combinations is the danger of fires starting at one place due perhaps to a beater striking a bit of hoop iron, a buckle from hoop iron, a broken spike or other hard substance, and then travelling through the machine.

Combination Machine.

A combination opener for American cotton may have: (1) Hopper bale breaker; (2) hopper feeder; (3) a lattice feeder having a small porcupine cylinder; (4) a Crighton to be used or not as desired; (5) an exhaust opener; (6) a scutcher.

Injury to Cotton.

Fibre may be injured at the scutcher by becoming stringy through over treatment; by cutting against the stripping rail; by setting beater too near the pedal nose; by having a wrong shape of pedal nose; by a very high beater speed; possibly by very heavy feeding.

Conical laps may be formed by more cotton drawing to one side of the machine than the other, due to that thicker side having more draft than the other, or to the lap rack being too high on the thicker side, or to cotton catching on the side of the machine between beater and cage. Perhaps exhaust openers are as liable as any to this particular fault due to some alteration being needed in the disc plates on the cylinder shaft, or in some one of the air regulators. Over feeding on one side of the machine may be due to any one of many causes, and the cotton should be watched from first feed to final delivery of the machine.

Increased cleaning capacity of modern blow-room machinery has led an eminent Bolton firm to adopt an exhaust opener to direct working without the narrow centre cylinder and two side beaters; two six-blade fans are used without the narrow cylinder.

Periodical Cleaning Through.

The parts of the scutcher which need most cleaning, apart from the usual weekly wiping down, are the lap end, the regulator motion, the beater bearings, the beater and cage bars, and the interior sides of the machine. Wiping down may be daily, bi-weekly, or weekly.

At intervals of, say, six weeks—more or less according to individual cases—the calender rollers and fluted lap rollers are lifted out and the bearings thoroughly cleaned and re-oiled. It should be stated, however, that in some mills this work is only done at longer intervals.

The rollers themselves and the cages may be well rubbed with a blacklead brush, or whitening or French chalk, and then the machine made good again. Also any parts inside machine which may be touched by cotton.

At intervals of perhaps the same duration the bowl box—if one be used at all—of the piano feed regulator may be pulled to pieces, all the parts thoroughly cleaned and blackleaded, and then replaced.

The same with regard to the beater bars and cage bars and insides of the machine, in order to make the passage of the cotton as free as possible.

This foregoing work is often done at the week ends, and it is often found convenient to do part of it at one time and part at another. Link and tripod regulators have largely superseded bowl boxes and need less cleaning.

Adjustment of Feed Rollers or Pedal Noses.

We should not be far away from good practice if for Tinnevelly we set the beater blades to be about $\frac{1}{8}$ or $\frac{3}{16}$ of an inch from the bottom feed roller, and about $\frac{3}{16}$ or $\frac{1}{4}$ of an inch away for Uplands, and, say, $\frac{5}{16}$ or $\frac{3}{8}$ of an inch away for Egyptian cotton. It must be remembered, however, that with the closest setting the blow of the beater will always be delivered on the cotton at more than 1 inch from the point where the cotton is gripped between the top and bottom feed rollers. As a matter of fact, if the cover of the beater be lifted up it will usually be observed that, say, about $1\frac{1}{2}$ inches of cotton are hanging down from the feed rollers. The setting at this position is ruled somewhat by the same general law that rules the setting of drawing rollers, viz. the longer the staple of the cotton and the further away the rollers, the number of laps put up together also affecting the problem. With the pedals in

place of the bottom feed roller it would be possible to bring the grip of the pedal and the top feed roller nearer to the striking point of the beater. As regards the rate of feed per minute, this would vary considerably in different mills, and will probably be somewhere between 60 and 80 inches per minute. Taking 80 inches per minute, this, of course, would be 80 inches to 2,400 strokes of the beater, which would equal 30 strokes per inch of cotton fed, with a two-blade beater making 1,200 r.p.m.

Referring to Fig. 15, in each case A is the pedal; B, the pedal roller; C, one blade of the beater; D, are the feed rollers. This arrangement is for long staple cottons. One feed roller only is used for short staple cottons.

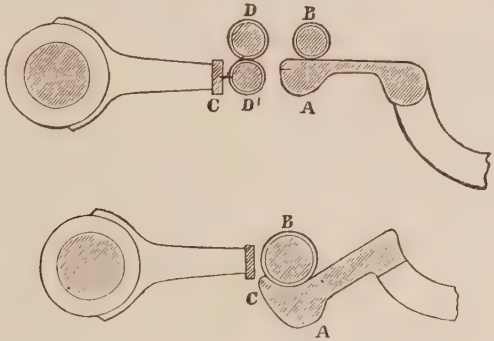


Fig. 15.

Faults in Openers and Scutchers.

It is possible that the faulty action of these or other machines may be due to defects in their construction or to derangements which arise in their manipulation.

(*a*) In actual work the author has often witnessed *bad edges* made on the laps by pieces of cotton sticking to the bars of the leaf extractor, or to the sides of the machine between the cages and beater. Defective linings to the ends of the cages, or *inefficient* covering up or recessing of the ends of the cages, will lead to the same evil, and so also thin feeding at the edges of the feed lattice.

In some cases bad selvedges have resulted from trying to make too thin a lap sheet, and in others by having dirty cages or air exits.

(*b*) *Uneven laps* often constitute a most serious evil, and may be caused by numerous circumstances, the primary of which are defective action of the piano feed regulator and irregular feeding of the cotton. This evil may result from the various doors and covers of the machine not being made a sufficiently good fit, and thus

affecting the air current. Possibly, also, by dirty dust flues and wrong speeds of fan. Flues too small or containing sharp corners, want of a good settling room for the dust.

The hopper feed may be wrongly proportioned in speed to the opener feed rollers, or some of its parts may be out of order.

As regards the feed regulator, the cone belt should be kept in a flexible condition and of the proper tension. Worn parts should be renewed, and slackness in the various studs, rods, and levers should be avoided.

Systematic weighing of the whole lap, and of small portions of lap, is essential to secure uniformity. Every opener or scutcher is provided with small adjustment screws to vary the weight of lap readily.

(*c*) Lap-licking is a serious evil in many cases, and may be due to using too much waste or short fibre in the mixing; or not having most of the draft in the top cage; or by too much resistance on the brake motion for hardening the lap. In extreme cases sometimes slubbing or intermediate ends are run round with the lap, or a drag board is made to rest on the lap during its formation, or the lap is thickened.

(*d*) If uniform laps and freedom from breakdowns are to be obtained from these machines, the utmost care should be taken to ensure really efficient cleaning and oiling of the various parts. Also all the straps should be kept well up in tension, and the various rollers and shafts should be known to work freely in their bearings.

(*e*) Sometimes the proper dropping of the leaf extractor door, or the removal of the fly and dirt from the proper positions, are neglected so much that some of the impurities begin to pass with the good cotton. The same effect may be produced with an excessively strong fan draft; while, on the other hand, if the air current be too weak, there will be a danger of good cotton passing with the impurities.

(*f*) If the beater speed be too high, or if the feed rollers or pedal noses be set too close to the beater, there will be a tendency to cut the fibre. Setting too far away, on the other hand, may tend to take the cotton forward irregularly, and nep and string the fibre by allowing it to hang down from the feed rollers and be struck by the blades repeatedly.

It is possible the latter evil may also be caused by worn beater blades. When it is remembered that in a two-bladed beater each blade strikes the cotton on an average upwards of 60,000 times in an hour, it will be understood that in process of time the steel blades may become worn. Sometimes the blades are double-edged, and the beater is reversible so as to allow of bringing the unworn edges into action. In other cases they may be re-planed.

(*g*) If the stripping plate be set too far away, it allows the

cotton to be carried round by the beater, resulting in *over-beating of the fibre.* As regards constructive evils, it is possible—

1. That the ends of the cages may be not properly recessed into the machine.

2. That rough places may be left on the insides of the machines, so that cotton will catch on them, the latter evil also resulting if the cages and various rollers are not well finished.

3. The various rollers, cages, beaters, fans, etc., may be not set to work with sufficient freedom.

4. The various doors and covers and the fan box may not be airtight.

5. The feed rollers may not be of sufficiently large diameter, or may be ineffectively weighted, resulting in the cotton being *plucked* from them by the beater, in unopened lumps of fibre.

6. Sometimes the pedal noses are not suited to the staple of cotton being used.

7. The various mechanical drafts of the machine may be wrongly proportioned.

8. Sometimes inadequate provision is made for adjustment of the feed rollers, stripping plate, and other parts.

Manipulation of Openers and Scutchers.

A blade beater may give about 40 blows per inch of cotton fed, but the number varies to much higher and lower than this.

The extra pair of feed rollers following the pedal roller is preferred for Egyptian and Sea Islands cotton, as giving a good round striking surface, and also a better chance for the regulating effect to develop.

The stripping rail may be set to be just a clearance from beater blades.

Quarter lb. variation up or down is the permissible limit in weight of full laps in some mills, while others allow a little more than this without any alteration.

Scutcher doubling of laps is a grand thing for mixing the cotton and helping to get uniform laps.

Sometimes a light lap is worked on one card and a heavy lap on another card in the same preparation.

In other cases too heavy and light laps are made over again.

Reliable workers are needed to ensure accuracy in this respect.

Conical laps are sometimes due to such causes as the following: Cotton catching against the sides of the cages or against the frame sides, between beater and cages; uneven feeding of the cotton; side dampers inside the vertical side passages not properly set; delivery flues and dust chambers too cramped; back drafts; improper setting of the dog heads or vertical racks, improper fitting of door or sides of dead-air box.

Uneven Laps.—Formerly these were often traceable to the bowl box of the feed regulator in which the bowls might be clogged with dirt or fibre or excessively dry, or the levers wrongly centred, or some of the parts worn. The bowl box, however, has in most cases been discarded in favour of one or other of the link, Tripod, or pulley arrangements in which about 16 pedals are paired off, then 8 reduced to 4, then 4 to 2, and finally one base lever linked up to the cone belt.

These are of small first cost, easy to clean, as durable as the machine, scarcely ever out of order, and give as good average results on the laps as does the bowl-box system.

The cone belt may be of wrong width, too slack or too tight, pieced with a clumsy overlap or of poor material.

The feed lattice should be tight enough to prevent slip. The cone belt should be approximately in centre of length of cones when the normal thickness of cotton is passing through, and the various levers should be correctly centred to give this.

With vertical cones the footstep washers may be worn, but many machines have horizontal cones.

Feed rollers should be weighted, driven, adjusted, cleaned, sustained, and lubricated correctly.

Fan speeds and fan dimensions, clean and smoothly running cages, correct adjustment of panels or dampers are contributing factors in obtaining uniformity.

In spite of the merits of piano motions, correct spreading and uniform feeding of the cotton to the machines are of primary importance.

Cages.—It is usually a convenient matter to entirely remove the top cage, and this may be done at the usual quarterly or other periodical taking down of the calenders and lap end for a fundamental scouring and cleaning. Cages, leaf, and dirt bars, and all adjacent to beaters may be examined and picked once or twice per day.

Occasionally it pays to clean and polish bearings of calenders, feed rollers, and other parts, possibly using paraffin oil to aid this work.

Sand, seeds, dirt, and impurities tend to escape by their own weight when cotton is sufficiently opened.

Flues, air passages, and insides of machine generally need frequent attention; for best result say a cleaning once per week.

An esteemed practical man who was once asked which part of an opener or scutcher needed most attention, simply said, "the inside."

Blackleading of parts and well brushing sometimes facilitates easy passage of cotton through an opener or scutcher.

Insufficient cleaning of cotton may be due to over-feeding, over-

production, or too high a speed of feed and delivery, or the lap sheet being too heavy per yard length. This must be considered in relation to the character of the raw cotton, the carding power, and the quality of finished yarn required. Beater and grate bars set too closely, beater blades in a dull condition, inadequate operation of fans, cages, and dust outlets, beater too low in speed, or too far from its bars, air entering at dead-air box are possible factors. If the beaters, on the other hand, are too widely spaced, or too much waste is used, the droppings may contain too much fibre or be too rich. Worn beater blades and beaters too slow may result in cotton being insufficiently opened.

If too much waste accumulates beneath the bars of the large cylinder, the bars of the dead-air box or beater bars, the air current may be more or less impeded.

The vertical racks should move freely up and down, and the lever or handle of the drop motion should move smoothly and unhesitatingly ; this drop lever will move more readily with machine working than stopped.

All beater, cylinder, or grate bars should be shaped and set to permit the exit of impurities to the maximum extent, while resisting the re-entry of waste or dirt.

Thin, light steel bars have often superseded thick heavy bars, with improved results, although of greater first cost.

Bottom doors of dust boxes may be lowered every two hours, but in some cases it occurs only two or three times per day. Travelling lattices beneath the cage grate bars have long been in use, but many makers take little notice of these lattices although they automatically remove fly and dirt from the dead-air boxes.

Adjustable circular panels may be placed in the sides of the machines for regulating to some extent the inlet of air beneath cylinder or beater bars. Also flat adjustable panels in the vertical flues.

Bad selvedges may be due to cotton sticking to stripping plate, or to the leathers at ends of cages, or to the machine sides, or grate bars from beater to cages. Denting of machine sides at lap making point and due to rough placing of lap roller in position, may be worse for the selvedges. Thin feeding of cotton at edges is a possible cause.

Lap licking means two adjacent layers of cotton adhering to each other when the cotton sheet is slowly unrolled at the next machine.

Due to such features as cotton too soft and clinging, excessive use of waste, excessively dry, soft cotton on the one hand or damp cotton on the other hand, excessive brake pressure when forming the laps, or the weights of the calender rollers not properly acting or not being near enough to the ends of their levers. The

old idea of remedying lap licking by using a larger top cage than bottom one is not now much believed in, but there is little doubt the problem is affected by the regulation and division of the air current between upper and lower cages, the upper cage possibly needing more help because of the cotton having to be lifted more to it by the air current.

Bad Selvedges. Thin Places in Laps.

Taking bad selvedges first. Generally this fault is caused by cotton or waste accumulating at some part of the machine. The longitudinal or leaf bars should be regularly taken out and cleaned, and then well blackleaded. Carry out this operation say once per fortnight regularly. Ragged selvedges may be caused by the cotton accumulating between the cages and the stripping plate at the sides. If dust or waste is allowed to accumulate on the leaf bars at either side of the lower cage it will cause bad selvedges. It is also a good plan to see that the insides of the framing from the beater to the cages are quite smooth so as to prevent any cotton adhering thereto. If the machine is systematically cleaned, such as the leaf bars, the inside of the machine, the surface of the cages — especially the ends—and polished with blacklead, it will do something towards producing better laps. There is more likelihood of the fault being present when old scutchers are used, as new scutchers have the framing constructed so as to form recesses or shrouds for the cage ends. Also examine the beater blades near the ends, and also the grid bars near the end to see if there are any rough places, or any oil about these parts, as this will cause the fault. It should also be seen to that the damper under the leaf bars is kept airtight, and the waste periodically removed a sufficient number of times daily. Regarding thin places in the laps towards the middle of length. Are the lap racks binding in any way about the middle of their upward traverse? Also examine the wheels actuated by the lap racks to see if there are any teeth missing; or the weight on the brake lever may not be in its correct position. Also examine the friction pad and friction wheel; you may find a rough place.

The "Tripod" Regulator.

Fig. 16 shows a form of feed regulator which has been largely applied, and is much similar to one the author saw working on a scutcher of foreign make at the Paris Exhibition of 1900.

The "link" and the "Tripod" regulators have been much applied both at home and abroad.

The "Tripod" regulator (shown in Fig. 16) has long been made by Messrs. Lord Bros., of Todmorden, and is so named by its essential feature, which is that a number of three-armed or tri-

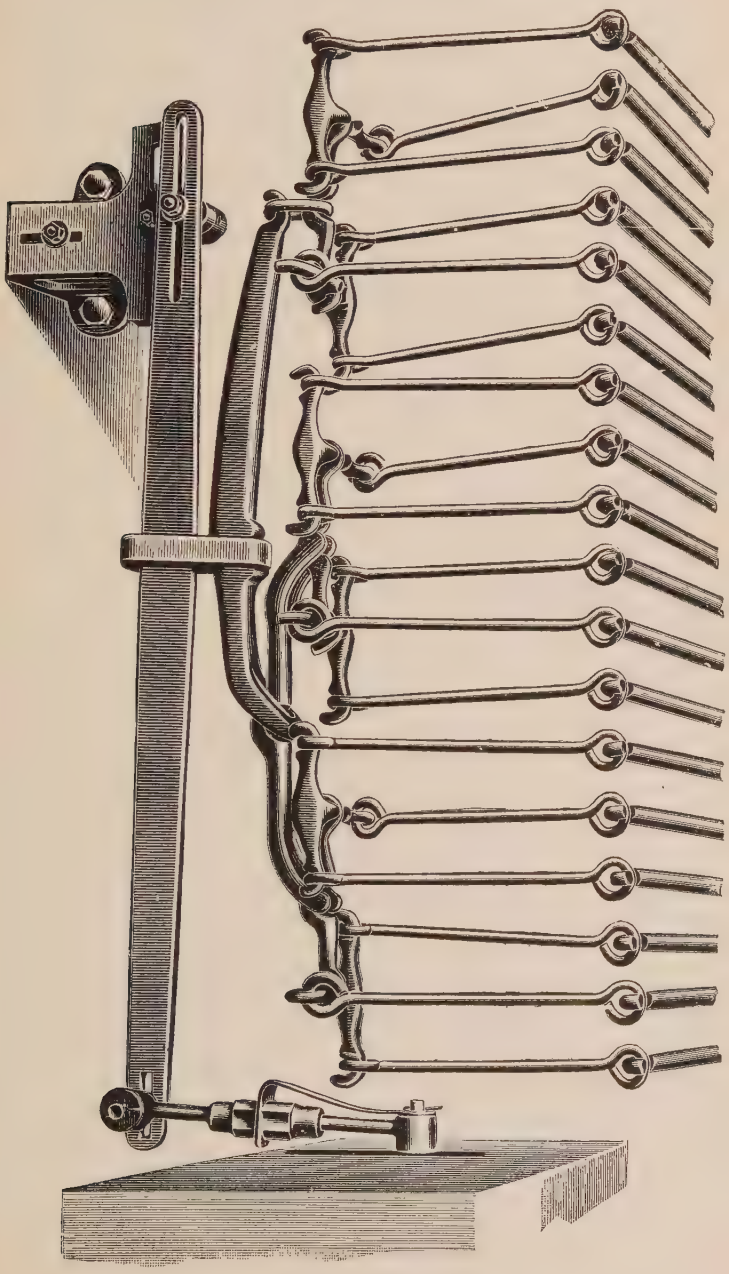


FIG. 16.

angular levers of various sizes are used in place of the ordinary bowl-box arrangement. The arrangement can be applied to existing scutchers.

Dating from about 1902, the makers themselves claimed the following advantages compared with the bowl box :—

1. Greater effectiveness.
2. Its efficiency is not impaired by any wear.
3. It never requires cleaning, as it will work when covered with dirt.
4. Time and expense of cleaning obviated, thus saving, also, chance of bad work through the regulator not being put together properly after taking to pieces to clean.
5. No repairs ever required.
6. No bowls between the pendants are used, so that the regulating cannot be spoiled through flat places wearing on such bowls.
7. No lubricant required.
8. Cannot get out of order.
9. Working much more freely than the ordinary regulator, it puts very much less strain, and consequently less wear and tear, on the feed roller flutes and bearings.
10. The cone-drum strap may be tight without affecting its sensitiveness.
11. Gives such accurate work that often for some time its adjusting screw need not be touched.
12. From its extreme simplicity it gives less trouble and greater "yard by yard" regularity than the bowl-box motion.
13. Can be readily applied to any kind of piano regulator.

Opener and Scutcher Laps. Variation Testing Apparatus.

The hopper feeder has superseded hand feeding to openers and operates with a quite reasonable degree of efficiency in giving the cotton in an approximately uniform manner to the beating instruments. Devices for keeping the amount of cotton in the feed box within reasonable limits; the evener roller action, and delivery boxes all help somewhat in this direction.

The so-called piano-feed regulator, however, remains as the chief instrument for obtaining a uniform sheet of cotton from the opener, and is very much assisted in this good work by the doubling of laps in the creel of the scutcher.

Unfortunately the combined action of the beaters, fans, and cages somewhat upsets uniformity in counts of lap and in the equality of lap sheets across their width.

Very clever sliver regulators have been experimented with at the delivery of cards, in order to supplement the scutcher methods, but the drawframe has always proved itself to be the best evener

known to cotton mills. Careful and close tests of short lengths of lap almost always disclose considerable variations in counts, having in view the fact that 6 inches of scutcher lap may represent 600 inches or more of card sliver.

Weighing of full laps is a very good thing, but offers little indication of variations yard per yard of lap. Even wrappings or testings of yard lengths are not really very searching.

The inventors of a once promising sliver regulator for cards made many tests of short lengths of lap, and assured the writer that variations of 30 per cent. were quite common. Well-conducted openers, scutchers, and cards ought, however, to do better than this. If opener and scutcher laps are unrolled in a good light, variations in density will often become very apparent to the eye.

Messrs. Cook & Co., of Manchester, make an independent apparatus designed to facilitate the determination of variation in the counts and density of laps in the variation parts of their length.

This arrangement consists of a miniature and sensitive regulator with mechanism to feed a lap through the same.

By means of connecting rods and levers, pivoted in anti-friction bearings, the resultant movement is traced in graphic line on a calibrated paper sheet.

A continuous indication of the average thickness of every portion of the lap is thus recorded. The rate of total leverage between the feed roller and recording stylus of this machine is almost double to that of the regulator of the scutcher, viz. about 80 : 1. But, inasmuch as the inertia to overcome resistance is vastly reduced the regulating pedals in the tester respond with much greater sensitiveness.

Not only is the irregularity of lengths of lap shown, but also a ready means is afforded of testing the effect of any alterations to the machine, whether it be in speed of beater or fan, size of fan blade, size or shape of flues, re-setting of piano motion, more level feeding of cotton, or other means.

In one case the writer found the bottom cage set screws had become loose and the cage was occasionally slipping. A greater blade area on the fan may give improvements, even with the same speed.

In a sense it is a pity the regulating work of an opener or scutcher cannot be done after the cotton leaves the cages, since the cotton often crowds on the cages in a more or less unsystematic manner.

The lap-recording apparatus above alluded to may be used in conjunction with an anemometer. It sometimes happens that the fan comes loose on its shafts.

The *anemometer* may be fitted in the middle of a board having an equivalent outline to one of the side upright flue panels and

temporarily fixed in the position thereof. The machine being then worked the anemometer will measure the air velocity in an approximately correct manner. Any desired alterations may be made, the air velocities noted, and the produced laps tested on apparatus.

If certain air velocities are proved best they may be standardised and other machines put to the same basis.

Tests should be made under full ordinary working mill conditions since the various air currents sometimes affect one another by back drafts, etc.

In a recent case of very bad laps the writer found that the dust chamber was of small size, the connection from double opener to dust chamber was also unsatisfactory. A straighter arrangement of larger exit flues and a larger dust chamber proved a permanent cure. All the walls and contact surfaces were made much more smooth than at first.

Whether the modern link motions which have displaced the bowl boxes, use plain pulleys, or simple bars or levers, it is customary to apply the links in pairs, and eight pairs, or sixteen links, is a favourite method.

Connections for other numbers may, however, be arranged on the link system, such as for 14, 17, 20.

With the 16-link arrangement a movement of $\frac{1}{16}$ inch on all the top pedal connections would represent a total of 1 inch on the lowest or final connection to the master lever at the bottom. With the standard 16 links and pedals all connecting points and linking up mediums are centrally disposed.

A narrow, thin belt of best quality leather is very advisable for the cone drums. Too wide a belt stretches over widths of cones having distinctly varying surface speeds, and too thick a belt has its outer surfaces distended over a distinctly greater arc of circle than is its inside surface, with a tendency for outside of belt to crack.

A belt of $1\frac{3}{4} \times \frac{3}{16}$ inch, of best quality, well stretched, with a wired jump piecing may be recommended.

Feed lattices out of alignment or not of correct tension often put extra work on the cone belt, and tend towards unlevel lap sheets.

The Cages of Openers and Scutchers.

It has been often argued that it was extremely advisable that the cages of openers and scutchers should be made of unequal diameters, the upper one being distinctly larger in diameter than the lower. As a matter of fact hundreds of machines have been made this way by different machinists. The chief argument in favour of this practice has been that it prevented, or at least much limited, the ever present evil of lap licking, by permitting by far the

greater volume of cotton to flow upon the upper cage. Practical mill men who have given any thought to the matter have repeatedly observed the fallacy of this supposed remedy for lap licking, since any number of actual examples can be adduced to show that lap licking has often proved a serious evil in openers and scutchers, whether the two cages were of equal or unequal sizes. There are certain detailed disadvantages attending the construction of cages of unequal dimensions and suitable framings and gearing, so that more than one important machine-making firm has reverted back to the idea of using two cages of equal diameters, each one being of reasonably large diameter and affording an easy flow of the air and fine fibre and dust.

It is not contended that the upper cage does not need a greater inflow of air than the lower one, because this becomes necessary if for no other reason than that of having to lift the cotton by the air current relatively much higher for the upper than for the lower cage. With equal diameters of cage this feature is readily met by having much larger exits from interior of cage into the side flues or chimneys at the ends of the upper than at the ends of the lower cage. For one or both cages the extent of those apertures may be regulated by end dampers, so that the proportionate flow of cotton to each of the two cages may in this way be subject to regulation.

Inside Dampers.

An important detail is the question of whether it is or is not advisable to use inside dampers. An inside semi-circular damper may be fitted on the central shaft of each cage, and can be utilised for blocking up the apertures of the cages at any points at which it is desired to prevent air from entering the cages. For example, the air is particularly wanted to enter the cages at those apertures which at any given moment happen to be fronting the passage of the cotton from the beater or cylinder to cages. This is sufficiently easy, but the greater difficulty is to absolutely close to the inlet of air all the apertures for the moment occupying other positions such as facing the calender rollers. Inside dampers permit of such facilities, and from this point of view appear to be desirable attachments to an opener or scutcher. Serious trouble that has arisen in the formation of the laps has ultimately been traced to the possibility of some of the air required to feed the fan draft being allowed to enter near the cage-stripping rollers—a defect much more likely to happen in the absence of inside dampers than if such are used.

Unfortunately, there appear to be certain more or less serious disadvantages attendant upon the use of inside dampers, and consequently many firms prefer not to use them. For example, the

usual method of securing the inside damper has been to set screw it to the full length central shaft of the cage, and to have that shaft stationary with the cage revolving on the ends. The usual form of cage is a somewhat weak cylinder, and especially in the case of woven wire cages, so that perforated zinc cages with round apertures have frequently been deemed advisable when inside dampers were used, and the cages have not been able to have any support excepting at the out ends at the bearing points.

Immediately the inside damper is discarded it is feasible and best to revolve the central shaft, and to secure the cage directly thereto. For example, there may be two inside spiders used and secured to the shaft by set screws at two different points in the width of the machine. With adequate support thus supplied at each end of the cage, and also at a point 16 or 18 inches from each end, the cage becomes very much stronger and much more able to withstand the pressure of lumps of cotton. It is to be remembered that the upper cage is not simply held down into position by yielding weights or springs, but it is sustained in fixed unyielding bearings, and in spite of the $\frac{1}{2}$ inch or so of space which separates the cages, there may occasionally be substantial pressure put upon the cages. Notwithstanding all this, even woven wire cages will endure the working stresses very well so long as they can have the internal support as explained above. As a matter of opinion the present writer considers the woven wire cage is much preferable to the perforated zinc one, as affording a freer passage for air, dust, and fine bits of fibre, while offering sufficient resistance to the bulk of the cotton. Neither are the spaces of the wire cage as liable to become choked as are those of the other cage. These are points which distinctly affect the working of any opener or scutcher.

The Regulating Motion.

Sometimes want of prompt lateral movement of cone belt to compensate for uneven feed of cotton has been traced to such causes as the following :—

Fork too wide for the cone belt ; wrong centring of some of the levers of the feed regulator ; slackness of fit in some of the parts of this motion, especially in the bowl box of the older form of motion when such is used ; parts of piano motion suffering from want of oiling and cleaning. There are effective motions which entirely dispense with studs as well as bowls. Sixteen pedals are now mostly used, but any numbers up to about twenty-four have been more or less used.

The fundamental principle of modern pedal and pendant connections for piano-feed regulators is to use cross-bars, levers, pulleys, or other contrivance each with a triple connection. In one

example it is a pulley with a chain passing round it, and each end of the chain connected with a pedal. The centre of the pulley

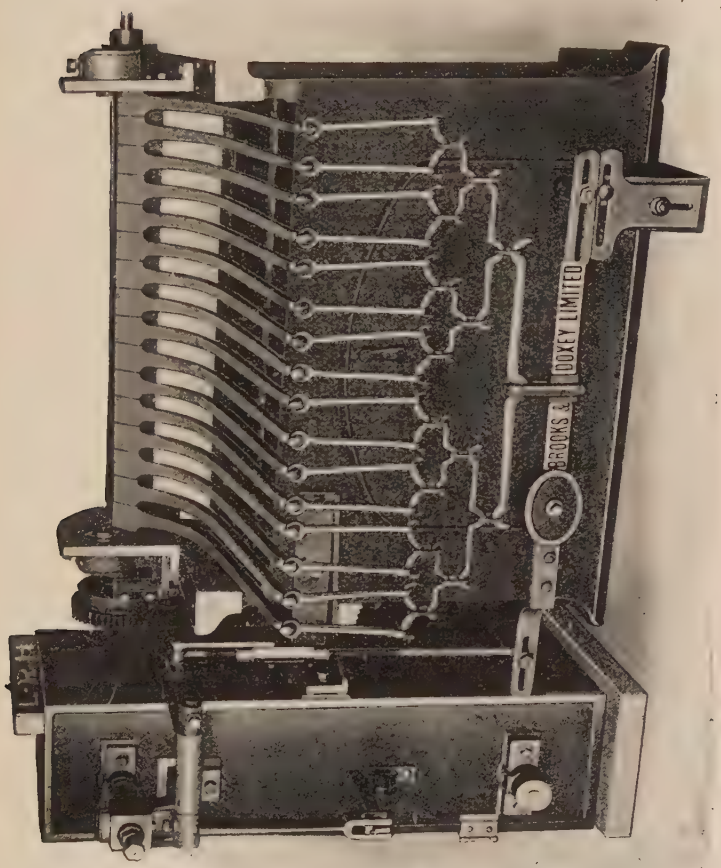


Fig. 17.

has linked to it a suspended chain which itself hangs downwards, passes round a second pulley, and is then reached up to the next adjoining upper pulley. Flexible wire is sometimes used instead

of chain. In many examples instead of the above pulleys and chains, full-fledged triangle or tripod cross-levers are used each upper one being bar-linked to a top pedal at either end and linked downwards from its centre to a similarly constructed lower lever; forming the well-known tripod regulator. In other cases the still more simple link bar is used instead of the tripod. In all these cases the bowl box is dispensed with and the lowest links, tripods, or pulleys are coupled directly to the main levers of the cone-belt forks.

Driving.—Beater pulley, 12 inches diameter × $4\frac{1}{4}$ inches wide for 4-inch belt, and may make :—

1,000 revolutions per minute for	Egyptian	With 2-bladed Beaters.
1,150 ,, ,, ,, ,,	American	
1,250 ,, ,, ,, ,,	Indian	
900 ,, ,, ,, ,,	Egyptian	With 3-bladed Beaters.
950 ,, ,, ,, ,,	American	
1,000 ,, ,, ,, ,,	Indian	

Table of Weight of Lap.

10	oz. per yard	=	·00190	hank	lap.
$10\frac{1}{2}$	,, ,, ,,	=	·00180	,,	,,
11	,, ,, ,,	=	·00173	,,	,,
$11\frac{1}{2}$	,, ,, ,,	=	·00165	,,	,,
12	,, ,, ,,	=	·00158	,,	,,
$12\frac{1}{2}$	,, ,, ,,	=	·00152	,,	,,
13	,, ,, ,,	=	·00146	,,	,,
$13\frac{1}{2}$	,, ,, ,,	=	·00140	,,	,,
14	,, ,, ,,	=	·00136	,,	,,
$14\frac{1}{2}$	,, ,, ,,	=	·00131	,,	,,
15	,, ,, ,,	=	·00127	,,	,,
$15\frac{1}{2}$	,, ,, ,,	=	·00123	,,	,,
16	,, ,, ,,	=	·00119	,,	,,

Uniform Cones.—It has been contended that the concavity and convexity of cone drums is not really essential on openers and scutchers, and some machines have been constructed with uniform cones and the cones of rather larger diameter than usual.

Dividing the cone-drum length of a scutcher into four equal parts and machine arranged for 4 laps. If we take particularly extreme cases of variation and assume that thickness of cotton moves from one equal part to two parts then it has doubled in thickness and requires a corresponding movement of cone belt. If the cotton moves from thickness 3 to thickness 4 in equal parts then this second change is not equal in proportion to the first although it may be equal in arithmetical progression. Proportional

increase in thickness rules the amount of regulation, and hence a greater variation of driven cone drum and feed-roller speed is needed for the first change than for the second one; this is given by the concave and convex cone drum. In actual practice under good conditions the belt seldom reaches the extreme diameters of cone drums, and the advocates of uniform cones contend that what is lost one way by using uniform cones is more than regained by reduced slippage of cone belt, and especially if the cones are increased in diameter, to become 4 × 8 inches. Possibly this argument applies more to openers with hopper feeders than to scutchers with 4-lap feed. An objection to larger diameter of cones is the greater cone inclination required.

Concave and convex cone drums are essential on bobbin and fly-frames so long as a uniform "let off" or ratchet wheel is used.

(*A*) *Thin Steel Beater-bars.*—A good many firms have applied this grid beneath their blade beaters. An essential feature consists in using an increased number of thin steel bars instead of a smaller number of thick cast-iron bars. Cast-iron bars are soon broken if made too thin.

Instead of possibly twelve or fourteen thick cast-iron bars perhaps twenty to twenty-four thin steel bars giving more sharp top edges for the cotton to come against, more spaces for dirt and short fibre to escape. Also the bar is made much thicker at the top or striking edge and thinner in the lower part, and of a shape which facilitates the exit of impurities, but resists their re-entry with the air current.

(*B*) *Extended Beater-bars.*—The scutcher beater bars have usually extended over about the first quarter or downward part of beater path, but in many recent cases they have been extended to encase all the lower half of the beater path giving many more bar edges and many more apertures for dirt and short fibre to pass through, even when using the thicker cast-iron bars which are not liable to bend out of shape (see Fig. 14).

(*C*) *Tandem Pedal Arrangement.*—The ordinary single pedal and one feed-roller arrangement is not the best for regulating purposes, and many firms use an extra pair of feed rollers next the beater partly because of this. The "tandem" or double-grip pedal motion combines good grip with good equalising. Each pedal contains two halves, one outside the other. The inner part gives the grip works with the pedal roller, and is weighted at its outer end but does not regulate. The outer shell also works on the knife-edge rail but does not reach the beater path. At its outer end it is directly coupled to the regulator motion. The outer pedal regulates and the inner pedal grips the cotton (see Fig. 14).

Single Scutcher.—A scutcher is now frequently single, i.e. it has only one beater; but double scutchers are sometimes used

having two of the bladed beaters in each machine. A scutcher is usually fed by 3 or 4 laps—mostly 4, but a few cases still exist in small plants of feeding by hand, or by hopper feed—this latter more especially in treating cotton waste. Widths of lap to suit next machine.

A Feed-lattice may be made of birch laths, fixed to four leather straps of good uniform quality. Lattice blocks are best of rather large diameter, turned and milled, and mounted on strong shafts of possibly $1\frac{1}{4}$ inch diameter.

Pedal levers of piano motion are best pivoted on a knife rail.

Cone Drums.—The shafts of cone drums run at a high speed and are best case hardened, and having long bearings with good lubricating cups and facilities.

The cone drum box may either be horizontal with vertical cones, or vertical, with horizontal cones, this latter being perhaps rather better for easily keeping the belt in exact position although the other may be made to work well.

It is so very important to keep a cone belt of correct tension that special belt-tightening arrangements are sometimes applied. In a good example the bottom cone drum may be moved up or down with its bearings, the highest position being assumed for a new belt.

To tighten the belt, the bolts are loosened and a special cam shaft turned with a screw key so that the cams force the bearings downwards to tighten the belt. The use of cams guarantees easy and accurate maintenance of parallelism in the cone drums. A special iron bar is provided to force the bottom cone up when a new belt is applied.

Spiked cylinders may be built up with hardened steel spikes riveted on to steel discs and carried on a steel shaft.

For an extra payment these cylinders and beaters may be made to work on ball bearings, there being a strong modern tendency for ball bearings for beaters, cylinders, fans, and feed rollers. Ball bearings for feed rollers is one method of easing the work and helping the efficiency of the belts or ropes for driving the cone drums.

The driving of the cone drums has usually been by way of the slow motion and calenders, following the favourite custom in cards, frames, and mules, of driving the feed roller from the delivery parts for draft-controlling purposes.

The high speeds of the cone drums have developed a tendency to drive the primary cone drum more directly from the beater by means of belt or rope.

In one case, at least, the thrust created by worm driving from resultant cone to feed rollers, on the end of this driven cone shaft, is much reduced by using a fourfold worm on the end of the cone

shaft, and reducing to the speed of feed roller by means of wheels. This takes the place of a single worm and more direct coupling of cone to feed. Worm wheels should usually be deeply geared.

The Crighton.

Perhaps weight on bearings is developed to its maximum extent by the Crighton or vertical opener, which is supported by a foot-step to which a great amount of attention has been given to obtain the best results. The business is increased in difficulty by the high speed of the Crighton and by the natural tendency of dirt and waste to get near to the bearing if not checked in every possible convenient way.

Steel washers to receive the shaft end, bearing surrounded by oil and water chambers, which can be gauged and replenished from the outside, better protection from dirt, have resulted in much greater freedom than formerly from breakdown and fire due to the vertical beater lower or chief bearing.

The application of ball bearings to the vertical beater shaft has been the means of reducing the friction of this heavy mass to a minimum.

Messrs. Tweedale & Smalley's arrangement is described in connection with Fig. 8 previously given.

It is quite common to fit the Crighton with rope driving and tightening pulleys, with a balanced pull.

Also with a two-way pipe, complete with valve, to allow of using a vertical beater or not, as required. If the cotton is deemed sufficiently clean without the Crighton part it is easy to fix the valve to this effect.

Extra Feed Rollers.—Some people now dislike the principle of striking cotton from pedals at the scutcher even when the latter are shaped to suit the length of fibre.

Feed rollers of $2\frac{1}{4}$-inch diameter may be placed next to the beater, preceded by a regulating pedal roller of 3-inch diameter; all three rollers hang carried in slide bearings to be taken out easily for cleaning. Feed rollers of 2 inches diameter may be obtained for short staple cotton, but there is a danger of detrimental springing of rollers in the middle when made of small diameter and for wide machines.

Beaters and Calenders.—Blade beaters are often of 18 inches diameter planed on both sides so as to be reversible.

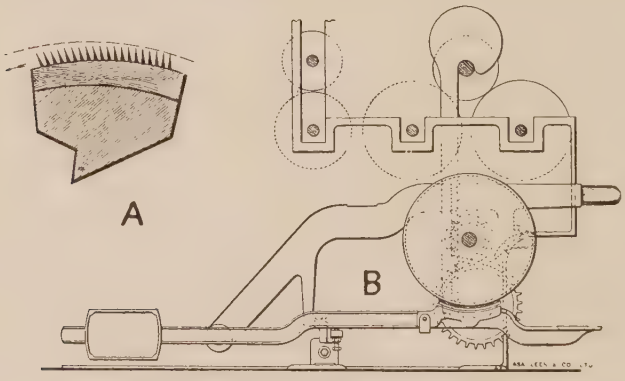
For some years the beaters have been mostly supplied with bearings on the Mohler ring principle. At the present time attention is being given to the question of ball bearings for openers and scutchers in such positions as cone drums, fans, the pedal or regulating roller, and more especially for beaters.

In some cases calender rollers are filled with wrought-iron shafts working in brass steps, and it shou'd always be easy to take calenders out and replace.

A beater door-locking motion should prevent the cover being lifted until beater stops, and should then prevent beater from starting until cover is down. At the same time it is all the better if the arrangement will permit of a slight hand turning for cleaning purposes with cover up.

Dust fans are sometimes made of 18 inches diameter with three broad steel wings. Dust box from cages to beater may have about thirty cast-iron bars, or thin steel strips containing fifty to eighty per set, cages of woven wire.

Lap-end arrangements should permit the lap rod being placed in the slip or lap roller, and the latter to be withdrawn on either side of machine.



BRAKE RELIEVING MOTION

Fig. 18.

Slip rollers of special weldless steel tubes, having forged wrought-iron ends bored up to take steel lap rods. Face of each lap end side fitted with a hard steel plate to resist wear.

Brake Motion (see Fig. 18).—It is possible to have a brake-relieving motion which relieves the pressure on the full lap when the machine knocks off so as to prevent the outer layers of cotton from rubbing into each other.

The fall of the drop lever of the full lap motion, by means of a small cross-lever, is made to release the brake-lever and ease the lap pressure. The vertical racks lift a little and are locked in the higher position.

Stop Rod.—It is the custom to drive the feed end of a scutcher from the delivery end either by belt, rope or gearing. This ensures that stoppage of delivery will also stop the feed.

It is better for stop-rod connections to permit an attendant to stop the machine from either side, either back or front.

Beater Bars.

The primary consideration in regard to the beater bars is that everything shall be done in regard to their strength, thickness, angle, space apart, and configuration, that will tend to permit the escape of the maximum amount of impurities and the minimum of good fibre. Dirtier the cotton may be and more open should be the spaces between the bars, other features being equal. If the cotton were very dirty the bars could be set nearer to the beater. The type of beater employed may affect this problem considerably, especially when we compare the vertical Crighton beater with the equal diameter porcupine cylinder, and especially as the action is similar all round the Crighton and the bars may be similar. The earlier bars should arrest the cotton somewhat more sharply than the later ones since the opening and cleaning become less necessary as the cotton travels across the bars. The air current should be so regulated that it will keep the cotton inside the bars, but will allow the dirt and some short fibre to escape.

In Fig. 14 previously given, at A is represented the "Tandem" pedal motion, at B the "Schaelibaum" beater bars, and at C the "Swan-neck" beater-bar arrangement.

These are three distinctive features that have received attention of recent years.

The "tandem" pedal gives the "close" setting and striking edge of the pedal nose, combined with the quick regulating action of the extra pair of feed rollers.

The eighteen or so of thin steel bars at B are indicative of a desire to get more cleaning spaces in beater bars, and also to prevent re-entry of any escaped dirt or fibre.

The "swan-neck" at C shows beater bars extended to a half circle instead of the more usual quarter circle of beater path.

Travelling Leaf Extractor.—In most machines a trap door is placed beneath the leaf bars which extend from the blade beater to the cages. This hinged door should be lowered at intervals—every two hours in some cases—to allow all the extracted material to fall on the floor for subsequent collection. Making a dead-air box at this position not only prevents air from entering at this wrong position but also gives a better chance for light, leaf, or short fibre to escape. At least one excellent firm has long made a point of applying a travelling lattice at this point, which automatically and slowly removes the impurities without attention from the workers, and diminishes the chances of "cat tails" and "dirt streaks" forming in the laps.

A slow intermittent motion is given to the lattice by a ratchet wheel, pawl, and lever, actuated by a cam fixed on the bottom cage shaft. A flexible flap is applied at each end, bearing against the lattice to prevent air from entering at these points.

Such devices are worthy of encouragement, and any disadvantages could probably be overcome.

Cages.—It is possible to have cages withdrawable sideways, made from one sheet of perforated steel, giving minimum obstruction to the air current, and eliminating the chances of seams coming loose.

Sometimes the lower bars beneath the blade beater are so arranged that the simple turning of a handle at side of machine will alter the angle of the bars, and either open or close the spaces between the bars. Closing these lower bars more would compel more air to enter at the upper bars and thus reduce the weight of droppings (see Fig. 14 at H).

It is possible to have a division plate which separates the air passages from the dirt chambers, this restricting impurities from re-entering the machine, but division plates should be used with judgment.

Air valves are sometimes applicable to automatically close the communication between the trunks and the opener, and to admit external air to the machine when the latter stops for a full lap.

Diameters.—Cylinders of porcupine openers may be 16, 24, or 41 inches diameter.

Hoppers.—Sometimes one hopper bale opener is used to feed two hopper feeders automatically, and it is possible to apply an automatic timing arrangement to give cotton to each hopper feed alternately.

It is possible to apply a lap doffing and lap-cutting arrangement for removing full laps without stopping the machine.

Arrangements of Dust Chamber, Chimney, or Ventilating Tower.

Method 1.—The blowing-room with cellar underneath the entire area, into which the fans of the exhaust opener and scutcher will blow. This is a really good arrangement under which to work. The depth of the cellar may be anywhere from 6 to 10 feet under the beam, and each fan or mouthpiece should point towards the outlet or chimney, and be provided with a light tin door to prevent back draught when the machine is not working. In connection with the cellar, there should be a dust chimney or ventilating tower extending somewhat above the highest point of the building, to allow of the free escape of air, the heavier particles of dust settling in the cellar, to be periodically cleared away.

This chimney should have a clear outlet, with an area equivalent

to not less than 10 square feet for each fan, and the opening from the dust cellar to the dust chimney should be of a similar area. It may be remarked that the above figures give the best results, anything less than these necessitates excessive fan speeds, which cause the licking of laps, and the fibres of cotton to be covered with dust.

Method 2.—A similar arrangement to the first, but with a portion only of the cellar used as a dust chamber, into which some of the fans blow direct, whilst others are connected by tin pipes 9 inches diameter, the mouthpieces of which should point towards the opening into the chimney.

Method 3.—Where conditions do not allow the whole of the blowing-room to be cellared, then under each lot of openers and scutchers it is customary to have flues of suitable dimensions, say 4 feet 6 inches deep, by 2 feet 6 inches wide, leading into a dust chamber, so that a man may enter to remove the accumulation of "fanny" or droppings from time to time.

Air Inlets and Outlets.

Most people now recognise the importance of having bigger flue areas than were formerly in frequent use, and settling chambers are also more often used than formerly. A considerable amount of very short fibre finds its way up the chimneys, especially when a heavy weight of cotton is passed through the openers and scutchers. Some cotton mills are in close proximity to fields belonging to farms, and farmers have often complained of damage done to their fields and cattle by the continual spreading about of such fibre and dust. For this various remedies have been adopted, such as putting a brush on the bottom of the chimney, or having a wire net across the top. The wire net, however, is very liable to become clogged up with fly, and to a less extent the same may be said of the brush, and then more harm than good results, owing to the chimney draft being spoiled. In extreme cases of this emission of fly and dust it is quite possible for a spinner to become liable to an action for damages. Probably the best and most genuine remedy is to provide an ample area for the settling chamber.

Split Laps.

One of the most distinguishing features of blowing-room machinery, as compared with the machinery of other departments in a cotton mill, consists in the extensive utilisation of air currents created by powerful and quickly running fans. These fans are almost, if not quite, always made with straight vanes or arms instead of curved ones, such as are found in connection with many ventilating arrangements. Some discussion has been raised upon

this point before now, but it is probably the case that the straight vanes are rather the cheaper kind, and are possibly somewhat more readily got to balance.

A most peculiar feature of this air current or pneumatic principle is that it is not necessarily and altogether subject to regulation and proper control by using the hammer and chisel, screw key, file, or other instrument, such as are used so definitely and successfully in cases of defects in some machines. A great many practical men are of opinion that the tendency towards making split laps is reduced by putting more draft in one of the cages than the other, as a lap will more readily split in halves when the cotton has been placed equally on both cages than when more of it is placed on one cage than the other. As is well known, this belief many years ago led to the practice of making the top cage larger in diameter than the bottom one—a practice which has been followed by various makers. Even when the cages are of equal diameter it will often be found that a greater portion of the top cage is left exposed for the reception of the cotton than there is of the bottom cage. This practice helps also to overcome the difficulty of the air current having to lift the cotton more against gravity to get it on the top cage than to get it on the bottom cage. It is a matter of fact, however, that many scutchers are working with cages of equal diameter, and split laps are rarely obtained from them, so that clearly this is only one of the features connected with the problem.

It would be difficult to find any equivalent for the air current principle in carrying the cotton away from the quickly revolving beater, and condensing it into sheet form, and therefore every effort must be directed towards properly controlling the air current. We have continued evidence of the vagaries of the wind in the streets of our towns, most of us being familiar with particularly windy positions at which sometimes it is difficult to stand, while at other positions near to it is comparatively calm. High buildings, particular dispositions of buildings, and also of streets, exercise a great influence in directing and controlling currents of air. This kind of irregularity on a less scale is sometimes found in openers and scutchers, and is all against the correct building up of the laps, so that everything should be done to create and maintain a steady, uniform, and equally distributed air current. When asked which part of a scutcher required most cleaning, a well-known expert said, "The inside of the machine." Innumerable bad edges in the laps are directly traced to cotton sticking to the sides of the machine between the beater and the cages, or to the dirt bars in this position.

The Flues and Dust Chambers.

In view of the importance of this subject it is most surprising to find what curious arrangements are at work in connection with

the outlet of the air and dust from blowing-room machines. In some cases the dust and air are simply blown into a small chamber directly opening out on a field or yard in such a manner that it is almost impossible to avoid back pressure, especially when the wind is in a certain direction.

Some time after first entering the mill the present writer was being shown round by the blow-room major, and was finally told to pass through a door in one corner. The door led into a very small room into which all the dust and air of several scutchers and openers were blown, and those practically familiar with such places will readily imagine the sensations of the writer and the condition of his clothes. This particular room was a case in point of no adequate provision for the outlet of air and dust, and yet there was continual trouble with lap licking. In the same arrangement every machine was fitted with an up-draft, but it is now well recognised that down-drafts are by far the better. Perhaps the best possible arrangement, where feasible, is to have the whole of the blowing-room provided with a cellar into which the whole of the openers and scutchers will blow. At one corner of this cellar or settling chamber there should be a chimney or ventilating tower extending upwards higher than the building itself so as to permit the free escape of the air and the lighter particles of dust. The heavier particles of dirt will settle on the floor of the cellar, to be cleaned out at proper intervals of time. The cellar itself should not have a depth of less than about 6 feet, and a little more than this, say up to 10 or 11 feet or so, is so much better. The ventilating tower should be sufficiently large to provide at least 10 or 11 feet of area for each fan blowing into it, and the delivery end or mouth of each exit pipe should point towards the chimney. Ten or 11 feet of area of opening for each fan should also be allowed between the ventilating tower and the dust cellar. It must be remembered that the penalty to be paid for small exit pipes, small cellars without other adequate arrangements, and too small chimneys, is the necessity of having high fan speeds, resulting in split laps. Each outlet pipe for air and dust should be provided with a light tin door to prevent back-draft when the machine is not working.

It often happens that it is only possible for a portion of the blowing-room to be cellared, and in such cases the outlet pipes of the various machines have to be lengthened out to reach the dust chamber or chimney, wherever these are placed. In extreme cases, as before stated, there are no cellars or settling chambers whatever, and the flues lead directly to the chimney or other outlet. The writer has a lively recollection of one case with which he was directly connected, in which the blowing-room was directly over the boiler house. Huge tin trunks extended underneath the floor of the blowing-room on the top of the boiler house to the door of the

same, and the man in charge had periodically to creep along these trunks and clean them out. These same trunks were altogether too shallow—only about 2 feet or so—and the laps from the machines gave continual trouble. When forced to be adopted at all such trunks ought to be something like $4\frac{1}{2}$ feet in depth and $2\frac{1}{2}$ feet in width, so as to permit of a man freely passing through. There should also be provided a proper outlet or chimney. Corners and turnings should be obviated or else made very gradual and rounded.

Inlet of Air. Air Currents.

It is a curious fact that the best place for air to enter a scutcher —as required for the fan draft—is through the beater bars, in opposition to the dirt, seed, or other impurities being ejected through the same bars. Many experiments have proved this the best position up to now. Hollow perforated beater shafts have been tried for air admission, but with little success. Air has been permitted to enter at the sides of the beater covers, but the best place has been found at the beater bars. A balance of working must be found by which a sufficiently strong air current is established to place the cotton on the cages, but the air current must not be so strong as to prevent the emission of leaf and dirt and some short fibre. To find and maintain the golden mean is a great factor in working openers and scutchers.

Curiously enough the heaviest impurities in beater droppings are found farthest from the bars on account of their overcoming air resistance. The present author's son devised and patented a perforated division plate for use beneath the beater bars of openers and scutchers in order to prevent impurities driven out from top or first bars from re-entering at the lower bars.

Faults in Finished Scutcher Laps.

For the fault of unevenness it would be advisable to examine all parts of the feed-regulator motion to see if they are in satisfactory working condition. The regulator should be kept well cleaned; the cone belt should be kept at a fair degree of tension. For the same defect care should be taken to have the laps presented to the back of the finisher in as regular a condition as possible, and everything affecting the fan draught should be carefully examined. For bad selvedges care should be taken to avoid any rough places on the sides of the scutcher between the beater and the cages. Every attention should be bestowed upon the efficient lining of the cages at the ends. A practice now sometimes adopted to improve the lap edges is to make the laps at the front narrower than those in the creel of the scutcher, and to repeat the narrowing process behind the card. Lap licking or "splitting" is often a very

serious evil in a spinning mill. When a large quantity of soft waste is used in the cotton it is sometimes the case that a drag board is allowed to press against the lap during formation. In other similar cases a number of rovings are allowed to run in with the lap during its formation. The more efficient blending of cotton using a less amount of short fibre, giving the top cage of an opener or scutcher more draft or air current than the bottom one gets, are all possible remedies for lap licking.

Driving of Cones.—There are mainly three methods of driving cone drums: (1) by belts, (2) by ropes, (3) by wheel gearing. The belt method is a very old one and is very free from breakdown, but is disliked by some partly on account of belt slippage.

The *Feed lattice* is sometimes responsible for errors in count and weight per yard of lap. These lattices may be so slack as to occasionally slip, or may be so tight as to over-stretch the belts and bind the lattice against the brackets too strongly; or the lattice shafts may not be parallel with each other and with the feed rollers. Sometimes the feed lattice rollers are connected by wheel gearing to prevent slippage or variation.

Feed Trunks.—Long exhaust feed trunks for openers are used to a limited extent for Egyptian cotton and especially for comparatively low numbers of yarn; but they are very extensively used for American and somewhat similar cottons. In spite of the use of improved full lap knocking-off motions which are supposed to give quicker stopping to feed than delivery parts, thick and thin places sometimes result from the collection of cotton or want of cotton in the exhaust feed trunks.

To prevent these bad places and to give greater production some attendants break laps off with opener working and dispense with the full lap automatic stop-motions.

Feed and Delivery.—The *feed rollers* vary from $2\frac{1}{4}$ to 3 inches diameter, thin rollers leading to springing in the middle, and thick ones preventing close setting. Lap sheets vary from 8 to 20 oz. per yard, and delivery rate may reach up to 32 feet per minute or so.

Beater Speeds.—Excessively high beater speeds may drive good cotton through the beater bars, and may give a curly appearance to the fibre and cut and weaken the same.

Low beater speeds do not open and clean the cotton sufficiently. Leaf and fibre drawn in again at the lower bars of the beater is sometimes a troublesome evil, sometimes checked by putting the lower bars closer together, sometimes by division plates, and sometimes by reduced fan draft.

Speed of Fan.—Particular attention must be given to the speed of fan, and actual experiment is often the only method of determining the really best speed to suit any particular case. Much

variation necessarily obtains in regard to speeds of fans even for the same class of cotton, this being due to the kind of beater, size of fan, and the constructional difference in the exit flues.

Low fan rates may lead to stringing the cotton by overtreatment, good cotton being driven into the dirt boxes.

High fan speeds may draw leaf in again, whip the cotton on the cages, and draw undesirable matter forward with the cotton.

Harder Cotton Baling and New Hopper Feeder.

Writing in 1922, it may be said that for thirty or forty years there has been more or less outcry against the comparatively bad make-up and bad tares of American bales. For thirty years the present writer has come more or less into contact with improved methods of baling—more usually taking some form of round bale, with better tares, and serious attempts at making standard sizes and standard weights of bales. The loosely packed, more or less ragged rectangular bale, still holds the field. Scarcity of shipping and transit facilities during the Great War directed attention to this feature somewhat, especially as freightage has remained costly.

Instead of a density of about 22 lb. per cubic foot, many bales have now a density of 32 lb. per cubic foot, which means a distinct reduction in space occupied in a ship and consequent reduction in cost. Some firms in America are installing high density baling presses.

When round bales came out about thirty years ago there was greater difficulty in the first opening in our cotton mills, and this difficulty has again arisen more or less.

In the case of a large opening combination it has been found that portions of unopened cotton have escaped the bale breaker and hopper feeder, and have become wedged under the regulating roller of the lattice feeder, or in other position, and have affected the regulator motion.

The difficulty, as suggested above, is greatest when continuous automatic feeding is done from bale breakers forward, instead of making separate cotton mixings.

Messrs. Platt Bros. have altered the construction of their initial machinery to meet such cases.

A new hopper opener comes between the bale opener and the ordinary hopper feeder so that an initial combination may be as follows: (1) Bale opener, (2) new Hopper opener, (3) Hopper feeder, (4) Crighton opener.

By this new combination, little or no more total space is taken up than before.

Platts have retained their distinctive feature of inclining the lifting lattice slightly backwards from the top—instead of the more

common method of inclining the top forwards as adopted by other machines.

For this backward inclination it is claimed that it economises space, allows large portions of cotton to be readily and more easily combed off the lifting apron by the evener lattice, and also allows more space for the latest arrangement.

A feature of the new hopper opener is the adoption of two weighted feed regulating doors, whose purpose it is to regulate the feed of cotton from the bale breaker to the new middle hopper feeder. The object is to control the feed of cotton so that a correct amount shall be maintained in the feed box or boxes of the hoppers.

This combination of new hopper opener, with the bale breaker, may be used in cases of stack mixings for extra treatment of cotton before reaching the mixing bins, especially in any example of mill practice in which extra opening may be wanted, as in the case of Indian cottons.

In the opinion of the author, we are always going the right way in seeking to utilise more and more the combing action of the parts of a modern hopper, and the tumbling and tossing action of the feed box, so long as other defects are not also introduced.

Opening, Cleaning, and Mixing Cottons (Ure, 1836).

"Were cotton wool delivered to the spinner in the same state as it exists in the pods of the plant, it would be sufficiently open and clean to undergo immediately the carding operation; but the wool has to be compressed so strongly in bags, in order to facilitate transport, as to cause a matting together and entanglement of its filaments into tufts, which must be carefully undone before it is presented to the teeth of the cards, which would tear the matted filaments asunder and ruin the staple. The first operation of a cotton mill, therefore, is to open up the cotton into its original spongy state, and at the same time to shake out any earthy or vegetable matters which may have been accidentally mixed with it. As perfect uniformity is a prime quality in yarn, and as this will depend not a little on the uniformity of the wool, this object is promoted by mixing together the contents of several bales of the same kind of cotton into one heap, commonly called a bing.

"The wool from every bag should be evenly spread in a stratum on a clean mat, so that, when several such strata are piled over each other, a section of them from top to bottom will afford an average of the whole stock. A tool like a hay-rake is sometimes employed to draw down and tease asunder the agglomerated mass of cotton, as it is wanted for the picking and other cleaning processes. Much skill may be shown in the suitable admixture of different kinds of cotton, in order to improve a weak stapled quality

and make it work into a good yarn. Soft, short, riband-like filaments are best adapted for spinning into wefts; firm, long and cylindrical ones, are best adapted for making the wiry warps and the lace thread yarns. To make this choice with final precision the tact of the fingers should be aided by the power of the microscope.

"Fine cotton, such as the best Sea Island, is generally cleaned and opened at first by the hand labour of women and children.

"For this purpose it is spread in small quantities at a time on an elastic table of tesselated cords, called a flake, through the meshes of which the seeds and dust are made to fall, by beating it with slender rods or wands, while the spring of the table helps to open out the knots. Such impurities as resist this separating process are removed by the fingers.

"Various machines for accomplishing the same object have been continued."

The willow, the original of the conical opener, and the lap-making scutcher were all apparently more or less in use when Dr. Ure published his cotton treatise in 1836.

"The next process after opening to which cotton is subjected in a factory is that of batting, beating, or blowing by a machine sometimes called by one name and sometimes by the other. Its object is to loosen thoroughly the filaments of cotton already partially cleaned by the hand or the willow, and to carry off, through fan-sieves, the remainder of the dust.

"The beating action is produced by flat bars, carried rapidly round, which strike with their faces the cotton fibres as they are slowly introduced from the feeding rollers, connected with the feeding apron-cloth. In each machine there is usually a double set of the beating or scutching apparatus from the last of which the cotton is frequently discharged upon the floor of the room, whence it is removed to the next machine, in order to be scutched again and lapped into a cylindrical roll. But it is better, for the batting machine itself turns out the cotton in a cylindrical lap, without the labour of gathering and spreading, and ready to be applied to the next machine, where the different sorts are occasionally mixed in lap form, before being finally made into a lap for the carding operation. In many fine spinning mills, batting machines are dispensed with and the hand picked and beat cotton is at once evenly spread upon the feed-cloth of the cards.

"Many opening machines have been made by Mr. Crighton of Manchester, and the beaters of some of the machines make 1,800 to 2,000 revolutions per minute.

"The scutching machine was originally invented by Mr. Snodgrass, of Johnston, in Renfrewshire."

Fans were effectively employed in blowing-room machinery by 1830 or so, and Dr. Ure says:—

"I have found experimentally that a fan 18 inches in diameter and 12 inches in width, moving its wings at the rate of 120 feet per second, supports by aspiration, in a syphon, a column of water 2 inches high, and when it moves at the rate of 180 feet, supports a column 3 inches. The chimney of an excellent drawing air-furnace does not support, by aspiration, more than one-seventh of an inch."

Cotton-Growing in Didsbury (16th August, 1922)—*Quality of "Crop" Nearly Normal.*

In the greenhouse of the Shirley Institute, Didsbury, Manchester, where the British Cotton Industry Research Association is studying and experimenting, nearly 300 cotton plants are growing. They represent the cotton fields of almost all the growing districts, many of them growing from seeds collected by investigators abroad.

In their work, said Dr. Crossley (director), at the annual meeting, it was essential that they should thus know the origin of the plants with which they were conducting research, and from that standpoint the collection was particularly valuable.

The greenhouse, he said, was itself an experiment. It proved last year that cotton could be grown in this country, but the main point they discovered was that the light in the Manchester area during September and October was not sufficiently strong to allow the cotton to mature.

This year they planted earlier, and the cotton is of a much better quality; in fact, it is considered very nearly normal. They would carry on for a little longer, but he thought it might be necessary to ask the Council to allow them to have artificial illumination during September and October, because it would be a real disaster if they lost the seeds and could not replenish them.

He would like the committee of the Empire Cotton Growing Corporation to get busy to enable them to have, say, half-bales of the cotton grown in other climates, so that they could then study the results better.

Mr. Kenneth Lee (chairman), reviewing the work of the year, said with the removal of all their initial difficulties, they had now got steadily to work, and progress was much faster and more satisfactory than in the previous year.

Australia's Helpful Cotton Guarantee Scheme (August, 1922).

The Australian Federal and State Governments guarantee cotton growers 5½d. a pound for the coming season, says an Exchange Melbourne message.

They will pay a third each, and it is hoped that the Imperial Cotton Association will pay the other third.

An official of the New South Wales Government pointed out recently that under the guarantee cotton growing will offer great scope for new farmers, as it will ensure them a safe position until they are well established.

The guarantee, he thought, would probably work out at something like 1s. a pound.

"It is debatable at present whether, without the guarantee, it would be worth the growers' while, to cultivate cotton, and it is more debatable whether the Government will be able to sell the cotton at a profit in Liverpool," was the opinion of an official of the Empire Cotton Growing Corporation. "That," he said, "will depend on the quality of the cotton grown.

"If the Australian Government sell their cotton at a profit in Liverpool the scheme will become economically sound, and, of course, the more cotton there is produced in the world the lower the price will be."

Ginning.

The proprietor of a merchant's ginnery sometimes combines two systems: (1) purchasing the seed cotton outright from the farmer; (2) regard the gin as a customer's gin and do the work on commission. Some people consider No. 1 as likely to give cleanest lint or ginned cotton.

It has to be remembered that seed is valuable as well as fibre or lint, and during the boom years such a good price was obtained for seed that the lint suffered to save the seed.

The seed at the ginnery is often stored in open bins, often ready for delinting or treatment to remove the waste. The merchant ginner may be able to select and grade the seed cotton and influence the treatment of it, and may influence the farmer to pick cotton cleaner and more free from leaf.

There are planters who handle their own cotton in cultivation, ginning, and marketing, and who will endeavour to place the cotton in its best condition. The same planters may gin for smaller cultivators.

Not only does cotton from different districts vary in staple and grade but sometimes also cotton from different parts of the same farm. The saw gin has only been improved in detail since its invention by Eli Whitney in the early days of the cotton factory system.

A saw-gin house busily engaged is represented as a maze of hullers, cleaning machines, boll-breakers, and the space not occupied by these machines is occupied by trunks, conveyers, and fans.

It has been suggested that instead of ginning the entire American crop in three or four months, some gins working night and day,

and gins speeded up so that injury to fibre results, better results to the cotton fibre would obtain by taking all the work more easily.

More careful picking, slower and more careful ginning of American cotton would probably increase its value, and Lancashire is more and more seeking "points on" cotton.

After all, it is to be presumed that practical persons who have been directly concerned with cotton ginning all their lives, have a better idea of what is best for them to do, than has an onlooker who uses the cotton but has never had anything to do with its ginning.

The fundamental principles of the throstle frame and the spinning mule, as left by Arkwright and Crompton 140 years ago, were so sound that the best mechanics in the world have been unable to supersede them; and apparently it is the same with the saw gin as left by Whitney over 120 years ago. Ginning by the saw gin is a comparatively simple, productive, effective operation, not beaten in these respects by any machines in a spinning or weaving mill.

The seed cotton may be removed from the store place or the farmer's wagon by an air current induced by a fan, and which takes the seed cotton above the battery of four or five gins, and the cotton is distributed to the feed boxes or hoppers which in turn deliver the seed cotton to the rapidly revolving saws.

The ginned lint may from this be delivered upon a travelling lattice, or else is trunk taken under an air current, and given to the bale press.

The war-time demand for cotton waste for army purposes, and the high prices obtainable in the boom years succeeding the Armistice led to an increased amount of delinting or second ginning, or treatment of seeds by extra machines.

The worst kinds of seed cotton, boll-breakers, cleaners, and grabbott separators, appear to have increased in use of recent years. From a spinner's point of view, it is desirable that all this be kept rigidly out of the marketed crop of ordinary American cotton.

The modern cleaning machinery in a gin house is somewhat comprehensive apart from the gins themselves.

The Macarthy gin—seldom found amongst the gin houses for ordinary American cotton—has the fibre pulled from the seeds by means of a leather-covered roller—aided by a doctor knife that prevents seeds from passing, and by a reciprocating beater blade which rubs the seed cotton rapidly up and down.

The knife roller gin never appeared to get a very firm hold.

The saw gin is almost universal for ordinary American cotton. A good sized saw gin may contain about 60 circular saws of fine teeth threaded on a centre shaft and kept apart by collars or washers possibly $\frac{1}{8}$-inch to $\frac{5}{16}$-inch thick. The rapidly revolving

saws protrude somewhat through the spaces of a grid so as to operate forcibly upon the seed cotton, the fibres being pulled through the grid by the saws, but the seeds being too large to pass through the grid. Saws may be 10 inches diameter, but sometimes 12 inches. Black foremen and workers are customary in a gin house.

Gin saws are made in great perfection, but require changing when worn. Sand present in seed cotton is damaging to the saws. Renewal of grinding of saws is decided by those in charge.

Worn saws will tend to string and nep the fibre since they permit fibres to be taken round and round, and possibly to come too close to the grids.

Gin cut cotton may result from ginning damp cotton, and saws not being stripped clean by the revolving brush. Stringy cotton formed in this way is more difficult to open in the mill.

Compressed Air for Cotton Cleaning.

Radical departures from the fundamental methods of opening and cleaning cotton in the mill do not yet take much hold in Lancashire.

The author inspected an expensive system established at an important Bolton mill just before the war but it has been taken out. The Youlten system is just now attracting attention and was fully explained, with models, at a recent lecture at Bolton Technical School. Really successful improvements have usually come through the machine makers, and we may specify hopper bale-breakers and feeders, conveying trunks, and better dirt bars. Experience proves there are always some impurities pressed into the cotton at the baling machine. When bale hoops are cut from the bale the cotton naturally opens out, and if left in this condition a long time, air would enter among the fibres and possibly tend to open, loosen, and "bloom" the fibres.

Patented methods have been devised to give the equivalent effect quickly, with the fundamental principle of passing through the cotton a rapid current of air. The cotton from the bale may be treated as usual by a bale opener giving the cotton to a travelling lattice which is enclosed in a box, the part of which is separated from the lower by a gauge screen.

Weight of Laps.

The method of adjustment in weight of lap by altering the screw is exceedingly convenient, but is limited in extent and should be reserved for temporary adjustments. Permanent and considerable alterations in weight per yard of lap should be made with the draft wheels or with the weight per yard of cotton fed to the

machine. The normal position of the cone belt should be near the centre to permit variations each way, and the constant brightening of cones and position of cone belt away from the centre is a sign of an alteration in draft wheel being required.

Fan speeds sometimes reach between the extremes of 1,000 to 2,000 r.p.m. A 41-inch cylinder may reach 700 or so r.p.m., and Crighton's reach over 1,000 r.p.m. A cylinder or beater 3 feet diameter 1,000 r.p.m. has a surface speed of—

$$\frac{3 \times 22 \times 1000}{7} = 9{,}444 \text{ feet per minute,}$$

so that 10,000 feet per minute may be taken as a very high speed for a large cylinder or Crighton opener.

Feed Rollers.—Thin feed rollers spring and permit plucking even if over-weighted to stop this. Such rollers should only be permissible with low speeds. The cross-cut shape is sometimes deemed to bite the cotton better than plain fluting.

Quick speeds and thick cotton need good diameters of rollers well weighted even for American cotton.

Very quick and very thick feeding will interfere with the cleaning and opening.

Widely set feed rollers may lead to irregular feeding and stringing of the cotton by want of clean beating forward of the cotton.

Bale-breaker Regulator.—It is possible to apply a regulator to a bale breaker if deemed worth while. In one American example the apparatus aims to automatically maintain a uniform supply of cotton from bale breaker to distributer by means of an electric switch operated by feeler in the feed box or hopper.

This switch is wired to another switch near the opener, which starts and stops a reversible motor connected to a speed-varying arrangement. The ultimate effect is to vary the speed of bale-breaker lattice.

Specification.

Details to be given when ordering Scutchers.

How many machines?
What width of laps are they to make? inches.
Will you have them to be fed by hand or by laps? If laps, how many?
To suit carding engines inches on the wire?
How many beaters in each machine? i.e. Is it a single or double scutcher?
Will you have self-contained driving? Revolutions per minute (usually 500).
Kind of beater, whether two or three blade or Kirschner?

Speed of line shaft?
Distance between line shaft and ceiling?
Largest size of drum? inches (usually 36 in.).
Speed of beater? Revolutions per minute (usually with two blades 1,500 revolutions per minute).
Diameter of beater pulleys? inches (usually 10 in. diameter).
When you face the delivery end of the machine, must the beater pulleys be on the right or left-hand side of it?
What kind of piano-motion regulator is required?
When must the above be delivered?
Counts of lap or weight per yard expected to use?
Kind of beater bars required?
Any other extra or special feature?

Approximate Working Speeds of Scutcher.

The chief and central revolving body on a scutcher is the beater, which receives motion directly from line or counter shaft, and distributes movement to all other parts of the machine. For a double-blade beater the revolutions may be about 950 to 1,050 for Egyptian cotton, and 1,100 to 1,200 for American. For a 3-blade beater the speeds are reduced below the above by possibly 150 to 200 r.p.m. The fan is usually the quickest revolving part of the scutcher, and may have possibly 1,300 or 1,400 r.p.m., obtained directly by belt from the beater, and not varying much for the two cottons. Also driven directly from the beater we have the slow-motion pulleys making possibly 300 to 350 r.p.m., and controlling the speeds of practically all the feed and delivery parts. Speaking in a general way these parts may revolve somewhat more quickly for American than for Egyptian cotton, because of usually greater production required and higher beater speeds in use; this applying almost more to the feed than to the delivery parts, because of greater weight per yard of scutcher lap for the shorter cotton. Approximate speeds of other parts may be 10 to 14 r.p.m. or the fluted lap delivery rollers, 950 for bottom cone drum, 760 for top cone drum, 9 to 14 for feed rollers, 11 or 12 for bottom calender, 15 second calender from bottom, with rather slower speeds for the higher calenders, 3 to 4 for the cages, 23 or 24 for the cage stripping rollers.

CHAPTER II.

COTTON CARDING.

Diameters and Cubic Contents of Sliver Cans.

STANDARD inside diameters of sliver cans in Lancashire have been 9 inches for all the finer cottons, and either 9 or 10 inches for the lower classes of cotton and coarser slivers. A 12-inch can will last almost twice as long as a 9-inch can.

Crowding of cans behind the machines and weight of full cans have restricted the use of large diameter cans in this country, but 12 inch diameter of can has often been used in America.

The author is inclined to recommend the use of the 12-inch can in this country to a much larger extent for thick slivers and low cottons.

Paper and fibre sliver cans have become extensively used during recent years, and are very much lighter than metal ones and easier to carry about.

Moreover it ought to be readily possible to arrange polished metal plates or slides for pushing the full cans along the floor from one machine to another.

Apart from all this the author is confident it would pay to employ stronger labour if necessary for can tenting work, so great is the advantage of the larger diameter.

We refer only to six ends up at the draw-frame and only to the coarser counts of sliver and lower classes of cotton. For eight ends up the back of the draw-frame would be too crowded unless a wider gauge of roller and delivery were used. For good class cottons and fine slivers there would probably be too much weight on the slivers, and fine slivers can get a good length of sliver even in a 9-inch can. The cubical contents of a sliver can vary with the squares of the diameters 9 : 12 :: 3 : 4.

$3^2 = 9$ and $4^2 = 16$, so that a 9-inch can only holds 9 parts, against 16 in the 12-inch can.

Sakel Cotton.

Long staple hard sakel has given a great deal of trouble to clean, open, and draft with satisfaction.

1. In certain cases card flats were speeded from 3 to 6 inches in increase, flat strips from 3 to 6 per cent. or so.

At 350 lb. per week of sakel cotton this gave every satisfaction.

The worm and worm wheel for driving flats soon wore out, but were then made of mild steel, and no more trouble was given. Super-carded for sewing thread firms gave satisfaction on this basis.

2. Ordinary softer brown Egyptian at 250 lb. per week, but flats 3 inches per minute did not give as good a web.

3. At mules non-adjustable polished cap bars of wider gauge stopped bad ends and did very well.

4. The slides for the bottom rollers had to be machine widened, and even then results did not satisfy for 50's super-carded in competition with moderate combed.

5. But much better spinning and better yarn were obtained finally by remembering that closer setting and larger drafts went together, and changing from 13 to 12 and then to 10 hank roving, thus giving a large draft worked wonders, and all for the best. Same idea cured bad spinning at high-class firm using Egyptian cotton.

Locking Motions for Coilers of Carding Engines and Combing Machines.

The comparative frequency and dangerous nature of accidents on cotton-carding engines due to the front or stripping being left open, led some years ago to the legal enforcement of front-door locking motions to cards. Many such motions have been devised, and few cards are now without them.

Of a less dangerous nature are accidents which have occasionally occurred in connection with card and comber coilers. Coiler accidents are more likely to affect finger ends, while front-door accidents were more likely to affect a hand or an arm.

On each coiler top there is a pair of small spur pinions and a pair of small bevels. Inside each long coiler box there is one pair of bevels, while there are usually seven spur wheels at the coiler foot on cards and combers. Coilers on draw-frames are differently and less dangerously geared.

At the time of writing these notes attention is being directed to coiler guards, and already more than one device for the purpose is on the market.

One successful underlying principle for a card is this: The lever for moving the doffer in and out of gear is so linked to extra levers and connecting rods for the purposes of the new locking motion, that neither the coiler top lid nor the vertical box door may be opened while the doffer is working. Moving the doffer handle or lever to disconnect the doffer also removes whatever finger, fork,

or other stop may have been locking the coiler top lid or the long vertical box door.

Arrangements may be still more simple in the case of combers, since it is quite a simple and easy matter to connect the main stop rod to the locking parts, so as to lock the coiler while the comber is running.

Dronsfield's Hints on Covering Rollers with Emery Filleting.

1. Keep the filleting in a dry room.
2. The filleting should simply be wrapped on the rollers; no glue or cement is necessary.
3. Mount the roller in a pair of steps or brackets to re-cover, and attach a handle to one end. Let one man turn while the other guides and stretches the fillet.
4. Cut one end of the fillet to the width of the slot; commence with the single slot at the left hand; pass through and secure the end by the clamp. Then wrap, keeping the laps close together, until the end of the roller is reached.
5. Before passing through the nearest of the three slots at the right hand, secure the fillet to the roller flange; it is worth while to get a small hand vice for this purpose. Then pass the end through the slot and secure.
6. Trim off the overhanging edges with a chisel or half-round file. The roller is now ready for use.

N.B.—The same instructions apply to the discs of traverse wheel grinders, but being only small they may be covered on a bench by one man.

Card Clothing.

Card clothing may be in fillets, sheets, and flats.

Sheets were formerly used for cylinders, but are now only occasionally used in the cotton trade for some of the coarsest and lowest kinds of cotton and cotton waste. In such cases the sheets of about 4-inch width stretch across the cylinder width and may contain small spaces without wire which permit seeds, leaf, and dirt to escape.

"Flats" or "tops" are specially made to the widths of the flats. Dronsfield's filleting is shown in Fig. 19.

Fillets are the accepted and almost universal thing for the cylinders, doffers, rollers, clearers, stripping brushes, and burnishing brushes of cotton cards. Filleted covering for grinding rollers is also very commonly used.

In cotton waste cards it is yet a very common practice to use for the taker-in fillets of leather or very heavy cloth foundation of several layers in thickness. Strong, serrated wire is securely

fastened into these strong fillets, and they are suitable for quickly re-clothing at the waste spinning mill after damage.

Metallic taker-ins are almost universal for ordinary cotton cards, and for these the strong serrated wire is punched out in lengths and set or wound vertically into specially cut spiral grooves in the taker-in. Metallic taker-ins are sometimes also used in cotton waste cards. Re-covering of a metallic taker-in is a rather special operation mostly done at a machine shop, but may be at the mill.

Tensions.

Cylinder fillets mild steel wire about . . .	230 lb.
,, ,, hardened and tempered steel about	325 ,,
Doffer fillet, mild wire	160 ,,
,, ,, hardened wire	225 ,,
Roller fillet, 1 inch wide hard wire . . .	120 ,,

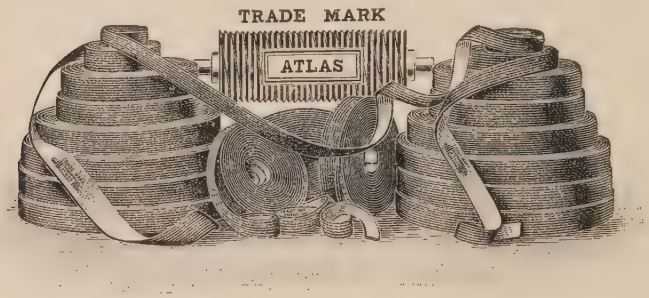


Fig. 19.

Kind of Wire Teeth.

Ordinary cotton card grinding is a mixture of top or surface and side grinding on the card teeth, the side grinding in the mill being developed by the lateral traverse of either the long grinder or the Horsfall, especially in the latter.

Needle-pointed wire is neither obtainable, maintainable, nor advisable for cotton carding.

The plough ground tooth is obtained at the wire-making establishment by grinding away the sides of the teeth down to the knee or bend. A strong round base or lower portion of each tooth is thus obtained, capable of gripping firmly in the foundation. At the same time the carding or upper portion of each tooth is left comparatively thin, fine, and capable of receiving portions of leaf, seed, dirt, or short fibre between the teeth, while offering a good edge for resharpening and re-levelling by the ordinary grinding rollers of the spinning mill

The plough grinding of the wire works is really side grinding carried to its most perfect degree, and producing a bevelled effect on each tooth from point to knee.

The most accepted wire for cotton carding is of hardened and tempered steel, plough, side, and surface ground ; with microscopic examination disclosing the teeth to have many fine abrasions, spikes, or corrugations which help to carry the cotton fibres and adhere to them sufficiently for carding purposes only. Very smooth, polished teeth, and needle-pointed teeth do not possess sufficient carrying power in the fibres.

At the card-clothing establishments machines are in use which provide means for mounting and stretching the clothing, with rollers for simultaneous side grinding, surface grinding for levelling purposes, and burnishing.

In every case of clothing a cylinder or doffer, the wood plugs should be carefully examined, and broken, loose, or sunk plugs replaced. Bulging plugs may be trimmed flush.

Re-clothing of Flats.—Before the introduction of the modern appliances for grinding flats on their working surfaces it was very difficult to obtain really good setting of flats after working some years, owing to the unequal wear of the flat ends. The working end surfaces of flats have always been subject to wear, apart from possible wear of the flexible or other equivalent bends, and the introduction of revolving rings for the support of the flats about 1890, to stop this wear, did not meet with satisfactory progress owing perhaps to grinding difficulties and occasional stoppage of rings.

Unequal wearing of the seatings or working surfaces of flats has naturally been in frequent evidence.

It has been the custom in this country to send the flats away to firms specially set out for testing the accuracy of the bevels in the flat, re-cutting defective flats to requirements, and then properly fastening the new clothing to the flats.

It is now possible to obtain mechanism for use at the spinning mill by which the flat ends may be tested for truth, re-milled to the proper angle or bevel, and then the new clothing applied.

Large firms, at any rate, may possibly find it profitable to employ people with the necessary time, skill, and experience for using the flats testing machine, the flats re-milling machine, and the flats clipping machine, all connected with the efficient re-clothing of flats. This work could perhaps run along with the special work of re-covering metallic taker-ins at the spinning mills instead of at machine shops, a machine for the latter being now available.

Frequent and costly trouble has resulted from faulty make or application of card clothing, and endless trouble and expense have resulted therefrom.

On this account many firms will only permit responsible travelling specialists to do the work of clothing. Perpetual re-setting trouble, blisters and swellings in the wire, bad selvedges to the cotton web, uneven work, cloudy webs, rubbing of parts and dulling of wire, have often resulted from faults in clothing.

It is now seldom that card wire is applied in this country without using card mounting machines.

Such a machine comprises a strong framing or bed for filling to the card, and containing the slide and leading screw, a tension head with tension indicator, and a jack for hand turning of the cylinder or doffer during application of clothing. The standard widths of fillet for cotton cards are 2 inches for cylinders and $1\frac{1}{2}$ inches for doffers, and a different traverse change wheel is carried for each, but it is only necessary to pass the jack chain from one to the other to allow for this.

In the tension head, coned pulleys are used to give a first tensioning effect about 50 lb. on the back of the fillet, then a hand-worked brake drum on the shaft of the coned pulley is compelled to slide over the faces of the cones so as to increase the tension on back of fillet to about 150 lb. Finally there is a weight plate in feed box, and a screw by means of which the tension may be raised to the desired limits of perhaps 350 lb. for full-width cylinder fillet, and 250 lb. for full width doffer fillet, but much less on the tail ends.

It does occasionally happen that a carder is required to cloth a cylinder or doffer himself, and perhaps more so in countries or districts having no regular clothier available at the time.

The Tail Ends.—The correct cutting and application of the initial and final "tail ends" is almost the most important detail in clothing the cylinders and doffers of carding engines. The fillet is more or less cut down so that it only gradually reaches its full width after about one full circumference.

It has long been the custom to arrange for the cut edges of the fillet to be on the inside of the fillet, and to keep a practically unbroken edge of fillet up to each edge of the cylinder. This is better for the selvedges of the carded web and less conducive to side waste than having the cut edges of fillet at the edges of the cylinder.

Take standard dimensions of 50-inch cylinder diameter, any width, 2-inch fillet, having eight ribs of wire. The diameter is slightly over 4 feet and the circumference slightly over 12 feet.

The more exact working circumference or length of one full round of fillet may be found by the preliminary fastening of one end of the fillet to a plug and winding the fillet once round the cylinder, and then firmly chalk mark the foundation and then unwind the fillet.

For the first half circumference half the width of fillet is cut

away, then for about 20 inches length in each case we remove successively three ribs of wire, two ribs, and one rib until a last short portion of full-width fillet is reached.

A special tool may be used for quickly removing some of the wire teeth, and a strong sharp knife for cutting the fillet. Sometimes the fillet is only cut away to half width, but in other cases only three ribs out of eight are left for the end portion of a tail end, but needs less tension and still greater care in winding, to prevent breakage of tail end.

Re-clothing of Rollers, Clearers, Strippers, Burnishers.

If desired a machine may be used at the mill for re-covering such rollers as above in the most efficient manner.

The framing somewhat resembles the grinding frame for rollers and clearers.

The bed-plate, tensioning, indicating, and traversing arrangement are on similar principles to those on the cylinder mounting machine.

The tensions recommended for rollers and clearers, hardened and tempered steel wire, fillet 1½ inches wide, 200 lb., or if mild steel wire is used, 140 lb. If the fillet is only 1 inch wide the tensions may be 130 lb. for the hard wire, and 90 lb. for the mild.

For 1 inch fillet applied to burnishing and stripping rollers 70 lb. is deemed sufficient, whether hard or mild wire is used.

The Licker-in Covering.

Hundreds of metallic licker-ins have been re-covered at one kind of machine shop or another, or in mill mechanics shops, by the use of an ordinary lathe, fitted with simple guide jaws in place of the usual rest for the cutting tool. The wire in such a case may be fed from a bobbin placed in suitable position, the work depending a great deal on the care and skill of the operator.

There are now available patent licker-in wire mounting machines which help materially in re-covering metallic taker-ins. Made by Messrs. Dronsfield, such a machine consists of a frame fitted with a slide on which slides the mounting head. At the left hand, independently on the floor, is a windlass, on which is carried the roller of wire. The hand-operated jack is screwed on the licker-in shaft.

Metallic cotton taker-ins are usually grooved to inch pitch with six to eight lines per inch, and the jack should traverse the mounting head 1 inch for one complete licker-in revolution.

The wire is fed from the windlass to the mounting head through a pair of jaws, which straighten out and tension the wire. Thence, the wire passes round a carrier, through guide studs, and under

the caulking bowl, to the grooves in the taker-in. The wire is caulked into the groove with a punch, by hand. Caulked ends may be soldered to prevent flying out when working. There are settings to keep exact line of feed, correct angle and pitch, and correct pressure.

The procedure must be repeated according to pitch and number of grooves. In some cases it is deemed worth while to grind a licker-in after covering, to set parallelism.

Specification for Revolving Flat Card.

A spinning firm may be required to specify such details as the following in ordering new carding engines :—

Diameter of cylinder. Diameter of taker-in before clothing. State of metallic taker-in. Number and width of flats. Method of fastening flats clothing. Description of card wire required. Number of machines required. Width of card on wire. Width of scutcher lap. Diameter of doffer before clothing. Approximate r.p.m. of doffer, cylinder, and taker-in. Single fluted feed roller and kind of feed plate. Kind of under casings for cylinder, doffer, and taker-in. Whether one or two more knives.

In regard to the coiler can, state inside diameter, length, diameter of can bottom, and diameter of can dish. Diameters of stripping and grinding rollers, with diameters of their shaft ends, and any special features. Kind and class of cotton to be used, and counts of yarn to be spun therefrom

Weights of 1 yard of back lap and of 6 yards of delivered sliver. Counts of card wire required for each part and kind of foundation or clothing for this wire.

Particulars of any special apparatus such as Philipsons' or other flats stripping brush or flats grinding arrangement. Kind of front-door locking required and whether accompanied by strap fork or not. R.p.m. of line or counter shaft. Diameters and widths of top shaft and cylinder shaft main driving pulleys. Hand of fast and loose pulleys when facing feed end behind the lap.

Constructional Notes on Cards.

The *widths* of revolving flat cards vary all the way from 37 to 45 inches on the wire.

Much used standards are 50 inches diameter for cylinder and 9 inches for taker-in, before clothing, $1\frac{3}{8}$ inch for flats.

Doffer diameters have tended to increase somewhat and run usually 24 to 27 inches.

Scutcher laps are usually $\frac{1}{2}$ to 1 inch wider than width on card wire to help the edges of delivered sliver.

Much used *speeds* per minute are 320 to 360 for the taker-in on

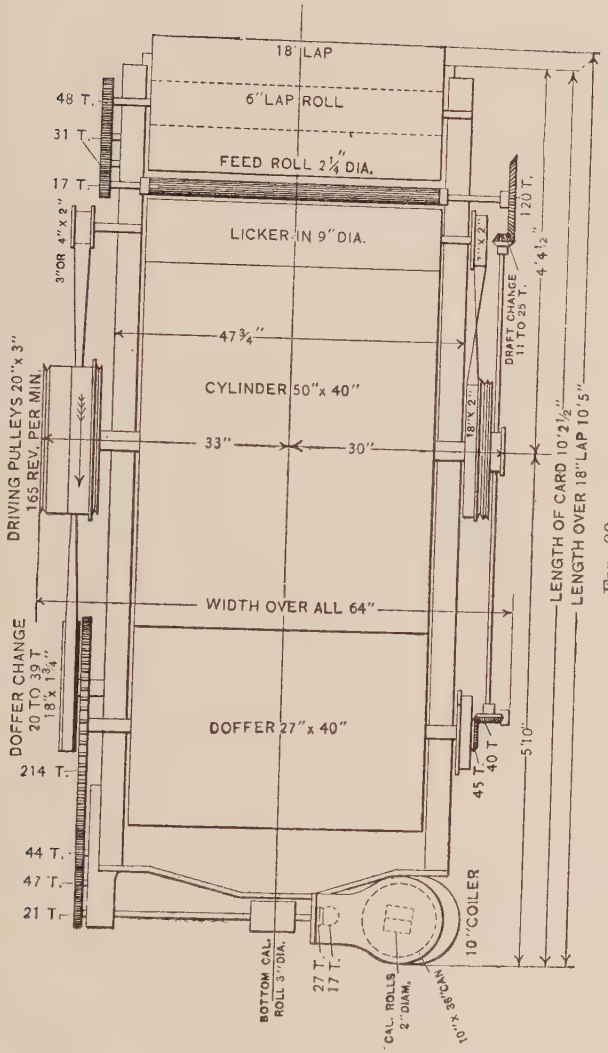


FIG. 20.

FLOOR PLAN OF 40-INCH CARD WITH 27-INCH DOFFER

Egyptian cotton, or 380 to 420 for Indian or American cotton; cylinder 150 to 180 r.p.m. These are for new cotton and not for waste.

Roller and clearer cards on cotton waste often run 80 to 100 r.p.m. for the cylinder.

Tinned iron angle bars are commonly used for the under casings.

Much used *can dimensions* are 36 inches in length, 9 inches inside diameter, $9\frac{1}{4}$ inches can bottom, $9\frac{1}{2}$ inches diameter of can dish. For coarse counts 10 inches diameter is often used and in America 11 or 12 inches.

Fibre cans are now used extensively, and are very much lighter than ordinary ones but scarcely so durable.

A *stripping roller* may be 7 inches diameter, $1\frac{1}{8}$ inch shaft ends. An ordinary Horsfall is 7 inches diameter with $1\frac{1}{8}$ shaft ends. Grinding fixings must be suited to roller diameters.

In this country hardened and tempered steel wire is customary, with cotton, wool, rubber-faced foundation for cylinder; cotton, wool, cotton for doffer and flats. Rubber is unsuitable for flats or doffer, and in hot countries is not even used for cylinders.

Fast and loose cylinder pulleys about 16 inches diameter are very suitable, but may reach up to 20 inches if counter or line shaft speeds demand same, the object being to obtain cylinder revolutions about 160 for Sea Islands and long staple Egyptian, 165 best American or ordinary Egyptian, 170 for Indian and low American.

In regard to carding engines accessories there may be: one stripping brush for about 20 to 25 cards when Cook's stripping apparatus is not used; one burnishing brush for about 35 cards or to suit management ideas; two dead grinding rollers and two Horsfall grinders for anything up to 20 cards, the long rollers for the flats and the Horsfalls for cylinders and doffers, although a little mixing of these is done as circumstances require.

The usual card change wheels are the side shaft change bevel for counts, and the barrow or doffer change wheel for production and doffer speed. An occasional tooth may be altered on calender shaft or at feed of card to get an exact tension on sliver or lap as the case may be. Line shaft or cylinder main driving pulleys for total speed of card.

Counts of wire vary within limited ranges, and fewer points or coarser wire is the accepted basis for lower kinds of cotton.

For flats and doffer the wire counts may be 90's to 100's for Indian, 100's to 110's for American and Brazilian, 120's to 130's for Egyptian. It is the accepted standard to make the cylinder 10 counts lower or coarser in every case. To get the wire points per square inch it is necessary to multiply the counts by 5 so that 100's counts $= 100 \times 5 = 500$ wire teeth per square inch.

Safety Devices for Carding Engines.

The application of front or stripping door locking motions to revolving flat carding engines has for some years been compulsory

by law. Any such good motion prevents the front door from opening until the cylinder is stopped, and afterwards prevents re-starting of the card until the door is shut.

In the same way, dust-removing apparatus for promptly removing the dust liberated by stripping has also become compulsory. These dust extractors add to the health of operatives, and tend to keep the cotton and machines cleaner, while the locking motions prevent accidents by operatives getting their hands between cylinder and doffer. There is now a good choice of apparatus by different makers for both objects.

Some attention has also been given to the question of having to reverse a card cylinder for grinding purposes. The usual method is for the grinder to use a crossed belt for grinding and an open one for working, or if the crossed belt is used for working, to use an open belt for grinding. The working belt may be used also for grinding or a spare belt may be carried about. In either case some little trouble is involved in the change, and serious accidents have resulted occasionally by operatives being carried upwards by the belts. The increasing use of strap forks for the main drive of cards has somewhat increased the trouble and danger of belt reversing.

Modifications of fly-frame differential motions have been devised for reversing a cylinder without reversing the belt. In a totally different device a spare three-grooved rope pulley is fitted to the doffer shaft for grinding, one pulley for about ten cards. The driving strap being then on the loose pulley, a groove therein carries an open rope which drives the doffer through the treble groove pulley.

The cylinder is driven backwards from the doffer by a crossed belt which connects cylinder and doffer for grinding.

From each of the other two grooves in the special pulley a cord reaches upwards to one of the two grinding rollers for cylinder and doffer. Coiler locking is now being advocated.

Driving of Doffer.—Direct driving from cylinder to doffer is almost extinct owing largely to the danger of the feed continuing after the licker-in has choked to standstill.

Single and double speed doffer drives may be applied by any maker, but are not very popular owing partly to danger of low speed being used when the card should be on fast speed. Pulley combinations for single and double speed driving are better than special wheel combinations, because the pulleys are quieter and less subject to breakdown. Single and double speeds may occasionally be useful for doffers of 14 or more r.p.m., using the full speed for working and the low for piecing slivers.

The indirect driving of doffer from taker-in is general and may take either two or four wheels in the train, but the open belt of the four-wheel system is largely preferred.

The centring of the small driving wheel gearing into large doffer wheel should be such that the barrow wheel connections shall not be likely to force the doffer against the cylinder wire on one side, or the doffer comb on the other side.

Railway Head.

What is termed the "railway head" appears to have received a good deal of adoption in the United States of America, and is still in use in many mills there, although, so far as the author can judge, its use is diminished in favour of the English system. The railway head contains an application of the cone drum regulating motion to what might be termed the first head or carding head of draw-frame. The illustration (Fig. 21) shows the gearing plan and driving arrangement of a well-known American make of coiler railway head.

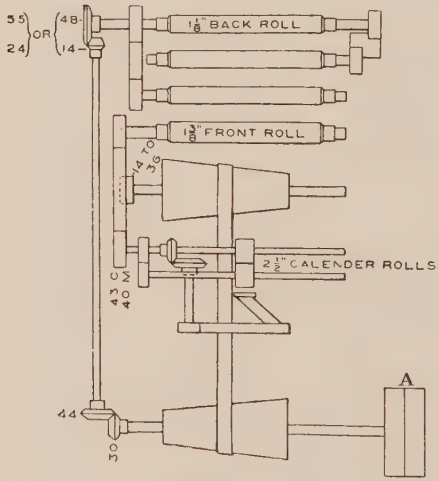


Fig. 21.

This coiler head is to be used in connection with cards, delivering into coiler cans. It takes the place of the first process or head of drawing, and it is contended that it gives a more even sliver as the basis of subsequent operations. Motion is received from the driving shaft to the pulleys at A, and the various parts of the frame are driven from the bottom cone shaft as shown. The principle of the motion is that the draft may be automatically regulated by the cone drums according to the thickness of the combined slivers.

While the back roller is driven at a constant speed the front roller is driven faster when the cotton is thicker, and slower when the cotton is thinner. In some cases the railway head has been coupled up to the carding engines in such a manner that several cards have fed one railway head.

Stripping of Flats.

No practical man will deny the importance of keeping the wires on the flats of a revolving flat card in good condition, and anything

which prevents the wires being broken out of the flat, or the bend being taken out of the wires, should be at least worthy of consideration by all practical men.

The flat stripping is a source of anxiety to all carders, especially where the revolving flat cards are a few years old. It is found that all the flats are not presented to the comb in the same relative position, this being due to various causes, chief amongst them being the elongation of the flat chain, and also by waste getting between the flats and the front disc or plate wheel, and, consequently, if the comb is set to one flat, that is, in the correct position on the disc, it will come into contact with the wires of those flats which, from the causes mentioned, are allowed to stand farther away from the disc, thus either taking the bend out of the wires or breaking the wires out of the flat, and, in either case, the power of the card to produce good carding is considerably diminished.

To Overhaul a Card.

We may begin with the feed part of the card, and we may set the feed plate, say, to $\frac{7}{1000}$ inch from the licker-in, taking every precaution to set these and other parts parallel to each other. As a basis we may take American cotton for medium counts of yarn, with the lap from the finisher scutcher weighing, say, about 13 oz. per yard. The gauge should be capable of being drawn along quite freely, although an equal pressure should be felt on it all across, and care should be taken not to have the gauge passing between the licker-in and mote knife when setting the feed plate. We may use the same gauge when setting the licker-in to the cylinder, first having the bolts in the licker-in pedestals slackened, and afterwards taking the precaution to screw these up well, or else the belts will pull the licker-in against the cylinder wire. Generally speaking, it might be considered good practice to set the licker-in under casing as close to the licker-in as it conveniently can be in order to prevent the emission of fibre.

It is as well to remember that the angle of the mote knives is of great importance as well as their distance from the licker-in.

Having finished with the feed parts of the card, the flats may next be adjusted, although perhaps some would prefer to set the flats first.

On many cards, at least when it is required to set the flats, it is necessary to take off the worm pulley to permit of the flats being turned round by hand by means of a handle or key placed upon the specially prepared end of the worm shaft.

Having selected a setting flat, we may take out a flat or two on either side of it.

Assuming three setting places with two supports between the

setting screws, the supports are moved out of the way, and the setting flat is worked round by means of the handle to the first setting point. Here adjustments are made to, say, a gauge of $\frac{10}{1000}$ inch.

The same procedure may be adopted with the other setting points working from back to front of the card, and afterwards going over the work from front again, as altering one setting point is apt to affect the setting at another point somewhat. Afterwards the two side supports on each side of the card should be brought up to just nicely touch the flexibles, and the flats replaced that had been taken out beside the setting flat.

Coming now to the doffer, this should be set as close as possible without touching, say, to a gauge of $\frac{5}{1000}$ inch if convenient.

The doffer comb need not be set as close as this.

The cylinder under-casing may be set wide at the front—say, easy to several gauges' thickness put together—but it should be a good deal closer at the back.

Before recommencing work every precaution should be taken to ensure that none of the wires are rubbing, a good plan being to turn the cylinder and doffer by hand with the engine stopped, meantime carefully listening.

Care should be taken also to have all the parts well screwed up, and to have all the bearings well oiled and all belts and cords replaced.

Erection of Flat Card.

The usual procedure will be adopted of having all parts well cleaned from the machine shop and transit grease.

Begin by placing the card sides on their feet in approximately correct position. Connect these by either the front or back stretcher.

Progression and identification marks are usually to be found on the various parts. In one case when a person is looking at the card from the feed end all parts of the first card on the driving side are both dotted and numbered, while on the other side of card numbers without dots are used such as 1-1, 1-2, 1-3 and upwards. The method of pinning important brackets and details in position materially helps erection in many cases. Early on, a quick, crude levelling may be done and wooden wedges used as temporary packings.

The cylinder pedestals should be fitted in position exactly as they left the machine shop; while the card is empty and accessible the pedestal caps may be removed, sufficient temporary assistance obtained, and the cylinder lifted into position, taking care to have the cylinder ends the correct way about for the pulleys, following some sketch plan or special instruction in this respect. The cylinder being in position the second stretcher may be put in place,

and both stretchers firmly bolted to the card sides by pins and bolts. The doffer fixings may now receive attention, and firstly the doffer pedestals may be fitted on card sides and then the circular sheet steel ends fitted to the doffer. Now lift the doffer into working position and then apply the pedestal caps of both cylinder and doffer. The doffer requires setting far enough from the cylinder to allow of both doffer and cylinder being clothed.

Definite steps may now be taken to get the card really and permanently level, careful reading of the spirit level on card sides, cylinder and doffer showing requirements, and permanent wood packings used if required in place of the temporary wood wedges.

The large cylinder and doffer fixed bends may next be erected on the card sides and fixed by bolts and pins as near to the cylinder sides as possible without touching.

Progress has now reached a point at which the cylinder and doffer may be clothed, and this is best done by an expert who specialises in card clothing, since the consequences of unskilful card clothing have often been very serious. It is customary and advisable to use a clothing machine for definitely applying, regulating, and registering the tension of fillet and traversing the fillet across the face of cylinder or doffer. Elsewhere in this chapter such a machine is illustrated and described, and clothing instructions are given.

After clothing cylinder and doffer, the latter may have a second preliminary setting to the cylinder using 9 or 10 gauge for a start.

Place the grinding roller in position on the brackets over the cylinder first and then the doffer, and set this roller by the grinding brackets to be (*a*) about 5's gauge from cylinder and doffer, (*b*) level with a spirit level, (*c*) as perfectly parallel as possible.

The first grinding may now commence as soon as convenient and may continue until the wire is sharp, and it is possible to set parallel to a 5's or 6's gauge all across cylinder and doffer for a complete revolution of each. Hollow grinding may occur from grinding rollers not being set perfectly parallel. Slow motion grinding by using special apparatus for driving the cylinder very slowly is still occasionally adopted for the first grinding of new cards, but otherwise receives very little favour. Between the erection of the first half of the card and the second part of the erection, there may be a period of two days or so to allow of the clothing and first grinding.

For the second part of erection we have the flats, the taker-in, the under casings, the coiler, some of the gearing and sundry brackets. As a beginning place one of the flats on different parts of the flexible bend and set the flexibles to be about 8's to 10's gauge between wire of flats and cylinder.

Then attend to the taker-in and set it about 7's from cylinder.

Remove taker-in and set the under casing to be concentric with the taker-in. The more usual method is to place a long shaft in the position of licker, traverse this with sleeve or collar having a pointer of same radius as the taker-in and set accordingly.

Apply the sheet steel cylinder under casing side plate making a good joint up to bend, front, and back.

The mote knife or knives may be adjusted to taker-in with the aid of an angle gauge.

The feed plate may be set to the taker-in by 10's gauge. Back details such as feed roller, lap roller, back wheels stand for full laps, back covers and weighting of feed roller may now be finished off.

At the delivery or front of the card we may now attend to the calenders, all parts of the sliver, can motion, coiler, comb box, doffer comb. Set comb parallel at about 7's gauge, and in one case it is the rule to set the comb 7¼ inches from top of card side when the comb is at the top of its stroke.

The back casing plate over the licker-in, and the front plate over the doffer may now be secured to the bend brackets, setting them as near to cylinder as possible without touching, and carefully noting if they are in the best condition and are smooth on the edges of the joints.

Attend to the taker-in and doffer covers and all the shafts and blocks round the rigid bend, except the back shaft and block which await the flats being applied.

The Flats.—The application of the flats requires special attention. Proceed to attach the flats to the two chains. As many flats as convenient may be placed on the bend between the grinding bracket and the bottom of the flexibles at the back or feed. Push these flats up and fasten the chain to prevent the weight of flats from pulling it down. Carry on in this manner until the flats can be locked under the star wheel or front block. Apply more flats until the flats may need winding round the front block.

With proper assistance the flats may be guided and wound round the front block by means of worm wheel arrangement. Carry on with applying the flats until they are passed over the bowls on tightening brackets and grinding brackets. The tightening brackets should be in position to allow of subsequent tightening of flats as required. Apply flats until they carry round the back block and then the back block and absent back shaft may be put in position. It will now be easy to finish off the flats, but care in detail is always necessary.

Follow on with the automatic stripping motion for flats including comb, brush and comb for brush. To set the flats a setting flat may be selected and a flat removed from either side of this;

wind the setting flat to every setting point and adjust flats as desired 7's or 8's gauge. Go over these settings again.

Before starting the card all settings, nuts, screws, pins, and gearings may be tested. Especially note that all bearings are well cleaned and efficiently lubricated, as it is no uncommon thing for bearings to get hot in new machines through some cause or other. As in the case of other machines it is advisable to run a card from 60 to 90 minutes without cotton, taking special note of high-speed bearings such as cylinder, taker-in, and grinding roller bearings New doffer comb boxes sometimes give a little trouble and really good oil should be used for these.

Manipulation of Card.

Setting a front plate wider at the top often gives heavier flat strips, and this setting needs watching and regulating. It is easy to compare strips from one card with those from another.

When the tension of the fleece of cotton leaving the doffer is regulated as accurately as it can be with the wheels available, it is usually possible to vary this tension somewhat by altering the height of the stroke of the doffer comb.

All grinding rollers for flats, cylinder, and doffers, need to be set grind parallel and straight across the width of card.

Any tallow or grease pots or oil bottles that are used require adequate attention. High speed bearings oiled and other bearings once per day.

Several times per annum there should be a thorough scouring or cleaning of the card, giving special attention to necks, bearings, collars, and the flats chains. Lubricate efficiently the links of flat chains, but don't let oil reach the wire filleting. Occasional use of the burnishing brush, or running the flats stripping brush quickly from cylinder, is sometimes recommended.

Keeping Cards in Order.

To keep carding engines in good working order it is necessary, in the first place, to see that "stripping" and "grinding" and "setting" are performed with sufficient frequency and skill. It is essential also that the cards be kept well cleaned and oiled, and with the straps and bands at a proper tension. Broken parts and damaged wire should be made good as quickly as possible.

The frequency of stripping and grinding varies considerably with different firms. For either of the above cottons stripping may be done from two to four times per day. With hardened and tempered steel wire some firms lightly grind the same cylinder every fortnight or every week; in other cases it is done once per month, while in still other cases a much longer interval is allowed to elapse between grinding.

As regards thoroughly re-setting, this may be done once every six months. Doffers may be set to cylinders rather frequently.

If the points were found to be very dull it would be best to first apply the full length or so-called dead roller in order to grind more quickly. Afterwards the Horsfall might be applied to give a final and more accurate grinding.

The Saw Gin and the Card Licker-in.

A cross section drawing of a licker-in and a drawing of one of the saws of a ginning machine obviously present many features in common, and one might be tempted from this to suggest that the licker-in of a card is just as likely to damage the cotton fibres as are the saws of a gin.

In this connection, however, we must remember one or two differences which are in favour of the licker-in action not being so dangerous to the fibre.

1. The saws of the gin have literally to tear or pull the fibres more or less forcibly from the cotton seeds, whereas at the carding engine, not even a closely set and short faced feed-plate offers much resistance to the licker-in in combing the cotton fibres forward.

2. At the saw gin the fibres of cotton are pulled through the interstices of a narrow grid in a manner which is likely to injure the fibres when the saws are not set and running with perfect truth in relation to the grid bars.

At the carding engine the licker-in takes the cotton *over* a grid not *through* it, and it is most unlikely that the cotton fibres will be injured by this action. It is not suggested that fibres cannot be at all injured by defective licker-in action.

Shirley Institute may possibly interest itself in such questions as this, and, indeed, the whole of the actions of the organs of a carding engine upon the cotton fibres, from licker-in to front plate and doffer comb, may well form the subject of examination, research, and official report.

Parallelism of Fibres.

The comber beats the draw-frame in making fibres parallel, for one reason, because the comber also takes out the short fibres which have bent and curved round the longer ones and acted as a roughening element to the whole.

Combing itself, represents the soundest fundamental principle for making hairs, filaments or fibres parallel. Parallelism of fibres produces lustre, softness, and good appearance in a sliver or roving.

Four pairs of rollers and three passages of the same cotton through draw-frame rollers, with six draft and six ends up, re-

presents the more usual draw-frame practice, and this does undoubtedly very materially help in the direction of making fibres parallel and slivers uniform, and thus helping us to obtain strong, level yarn.

The writer has wondered whether better results would not be obtained by altering the method of driving draw-frame rollers, combining five or six pairs of rollers in the same machine and using smaller middle drafts, in order to prevent bad ends and roller laps and possibly increase parallelism of fibres.

At the mule the writer many years ago made a number of tests with a larger draft between back and middle rollers than the standard of approximately 1·08 to 1·12, but no better results were obtained.

From the same cotton, the yarn in which the fibres are most parallel will be the roundest, strongest, brightest looking, and smoothest. Brightest because the fibres received and reflect the light, whereas crossed fibres scatter the rays of light in all directions. Such yarns will give cloth that will weave better, and will bleach, mercerise, dye, and finish better.

Mr. J. H. Dawson referred in an article to a patent applied for October, 1918 (No. 133,800), whose object is definitely to obtain a greater degree of parallelisation among the cotton fibres, than is usual in carded yarns :—

"In the processes of preparing textile fibres for spinning into yarns, advantage is taken of the fact that by repeated doubling and drawing out of the material, a better parallelisation of the fibres is obtained.

". . . There are several places where the material passes from the nip of one pair of rollers to the nip of the next pair of the series, or from the periphery of one to that of another, where the distance is such that a pulling or tightening effect has to be maintained between the delivery point and the receiving point in order to keep the tension at such a pitch as to prevent, as far as possible, the bagging, puckering, or curling of the fibres comprising the web, sliver, or otherwise described material under treatment. In practice this is inefficiently performed by existing means, cotton fibres are imperfectly laid, selvedges in some cases get torn or broken, in others puckered and condensed; as it is impossible during the subsequent processes to entirely eradicate, or eliminate the faults thus caused or formed, much fly and waste is then and afterwards made.

"The object of this invention is to incorporate in all places, and at all points where possible, in any machine or section thereof, along with the existing draft hitherto obtained by differential surface speeds, a positive drag or retarding action which produces a combing, smoothing down, and polishing effect upon the material thus treated.

"Also to introduce, where beneficial, this positive drag in all places, at all points, where under existing circumstances, there *is no* draft, either regulated by differential surface speeds, or produced by other means.

"The foregoing objects are attained by causing the material in its working passage to maintain frictional contact with one or more wires, small rods, or similar contrivances, made into the form of a grid when more than one wire or rod is required.

"The material is passed in some cases between the arrangement of wires, and there is frictional contact both under and over the web or sliver; or it may be passed simply over the wires, or simply under them, thus being in frictional contact with one side only. The wires or rods may be of any suitable gauge or thickness, and may be either smooth or have very slightly serrated surfaces formed by milling, screwing, or any suitable means. The distance apart of the wires may be such as to suit the varied positions and conditions in which they are expected to perform their functions, which are to smooth down, and comb, or 'brush' the fibres, and thus to improve their parallelisation of condition for the next process."

Practical examples and tests were made in order to show the actual results.

Card-room Notes.

Modern electric lamps can be safely held under beater bars or under a licker-in in order to note what is occurring in regard to fall of fibre, dust, leaf or other impurities.

At the scutcher many methods of air entrance have been experimented with, but these have come back to the custom of allowing the air to enter through the beater bars, although the bulk of the impurities in going out, meet the air coming in.

The heaviest impurities such as seed, are driven into the farthest parts of the dirt chambers.

Experiments with different forms of beaters, dirt chambers, grids and dirt bars have been very numerous, compared with the degree of success in improvements.

About 1912 the author's son patented a device for preventing the re-introduction of leaf or other matter through the dirt bars.

A perforated division plate was introduced in the space below the dirt bars and would permit air to enter but not impurities.

The perforated division plate was automatically cleaned, and the initial bars were left unshielded as before.

Reduced Cotton Qualities.

Referring to American cotton more especially, it is often suggested that the average supply of cotton is now much inferior to former conditions.

There is doubtless a good deal of truth in such statements.

Many Lancashire spinners want better cotton than formerly, especially if they are ring spinners. Revolving flat cards are known to give cleaner but weaker yarn than the former roller and clearer cards; marks and gradings vary with different years.

There is good cotton in the world for some people. In June, 1922, a Peruvian gentleman over in England for cotton machinery, remarked to the writer that they had good spinning in Peru because they had good cotton near at hand.

In spite of these remarks a great deal of inferior cotton has come from America of late years.

"Joint Inspections" of "Operative Spinners' Association Masters' Federation" on the spinning side, and of Weavers and Winders' Unions with manufacturers' representatives, have revealed many cases of bad work which can only be laid at the door of inferior cotton.

A good deal of raw cotton now handles "too soft." It is too "wefty" and short of "grip." It has no "bone" or "bant" in it. The so-called same marks as previously used, with similar mill treatment in every way, do not now always give as good spinning or as good yarn as formerly and there is more waste loss, fly, and bad ends.

In an example of watching a bad end forward from the front trumpet of the finisher draw-frame, through the fly-frames and right into yarn, single roving into counts 33's, the lea containing this defective cotton only pulled 40 lb. against 48 lb. for a good lea.

An increased amount of licker-in fly is a feature of more "waste" cotton, especially in the "fuddy" part as distinct from the leaf and seed. The waste "baggers" in some mills have noticed that a less weight of waste can be got into a bag than formerly, giving this as one proof of the presence of more short fibre, the weight per bag dropping from 2½ lb. to 170 in one case.

The high prices of raw cotton prevalent in 1919-20 probably caused more attention to close ginning and what may be termed second ginning or delinting at the ginneries. "Linters" or second ginnings were much in demand during the war, and it is to be hoped this linters does not now come along with the good cotton.

Presumably cotton will deteriorate in quality if there is any neglect in breaking up the land properly in "bedding out" in hoeing, in using fertilisers, or in seed selection.

In times when there is ample cotton to select from spinners will soon learn to avoid the cottons which contain an undue amount of very short fibre.

Card Cans.

There are many makers of card cans for use at cards, draw-frames, combers and slubbers.

Special spiral springs are sometimes used inside these to hold the sliver higher up when there is not much sliver in the can.

Corrugated cans are considered stronger than plain ones.

Fibre cans are very much lighter than steel or tin cans and some of the so-called fibre cans are reasonably durable while others are soon damaged.

One firm makes a corrugated steel can, with patent solid-drawn seamless, Siemens steel binder and three-spring buffer bottom. Also a good quality of vulcanised fibre can, the same material being also used for electrical and mechanical work, since it is a good non-conductor of electricity.

Variation on Flat Strips.

(*a*) The wire on some of the flats may be damaged, or the ends of the flats may be worn irregularly, thus giving a different angle to the flats, or parts of the chain may be irregularly worn, or the wire foundation may be slack on some flats. (*b*) The wire may be damaged at one part of the flat and not at another, and the same remark applies to slack foundation. The front plate may be set farther away at one end than the other. The wire may be harder and rougher and not as well ground at one place as another. (*c*) A common cause of the flat strips being too heavy is the front plate—between the last flat and the doffer—being too far away. There may be an improper angle in the teeth of the flats, such as having too much "keen." (*d*) A common cause of flats stripping badly is the stripping brush being set too deeply, and this has frequently come under the author's notice. When an operative sees the flats stripping badly—and has not had previous experience—he at once naturally gets the brush to touch the bottom. This, however, aggravates the evil by fastening the fibre at the bottom of the teeth. Defective wire is a common cause of bad stripping.

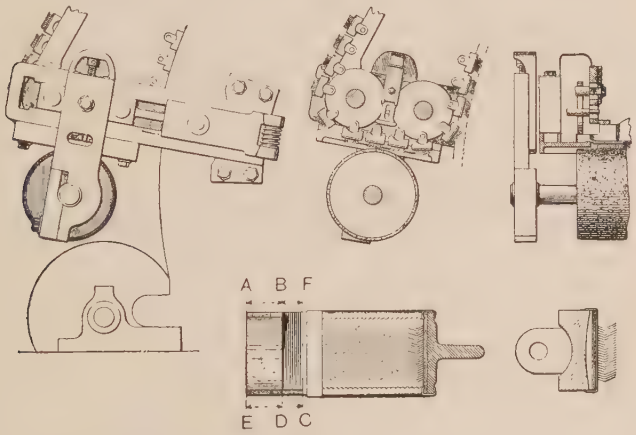
Cloudy Webs.

Speaking generally, irrespective of maker of card, there are many good carders who immediately make a point of examining the feed parts of a card in the case of cloudy webs to see if there is irregular or defective setting of the feed roller, taker-in, and possibly the back plate. An uneven lap sometimes allows plucking, and therefore gives cloudiness.

Temporary cloudiness of the web is sometimes caused by neglect of stripping, and the carder generally has an idea when such is the case. Very wide setting of various parts will cause cloudy webs, and this remark applies, perhaps, more to the setting of the doffer from the cylinder than to anything else. Neglect of grinding will cause cloudiness.

In some cases cloudy webs have been traced to the influence of air currents acting on the cotton on the face of the cylinder, more especially at the front and back plates, and in other cases the cause has been found to be the defective condition of some parts of the wire. Bare places may be caused by defective laps, and by one or two of the things which also cause cloudiness. The remedies are obvious.

Neglecting to collect fly from beneath the card may lead to cloudy webs, and especially from the front edge of the under casing. By reversing the doffer by hand such accumulations may be brought off with the doffer, and this is often the first thing that grinders do.



A. B. C. D. SLIDING SURFACE WHEN GRINDING
A. B. C. E. SLIDING SURFACE WHEN CARDING
B. F. CLEARANCE FOR RAISED SURFACE ON SLIDE WHEN GRINDING.

FIG. 22.

It would be an easy and profitable thing to first of all strip the card well, and note the effect on the web. Afterwards the gauges might be inserted in order to get an idea of the distances apart of the main working parts. These being all right, the wire might be examined carefully as to whether it required grinding. It may be taken as a fundamental principle that defective stripping, grinding, and setting are fruitful causes of cloudy webs. The wire itself, of course, in process of time requires renewing. The lap behind the card must necessarily receive early attention at our hands, especially with reference to the special defect of unevenness, as it will be practically impossible to secure regular web from an irregular lap. The edges of the lap can soon be examined, and if any doubt exists

as regards the regularity portions of two yards long should be unwound from it and carefully examined and weighed. Imperfect action of the doffer comb at times tends to bring the web off the doffer in a cloudy and uneven condition, especially the first thing on a cold frosty morning.

Anti-flexion Grinding (Fig. 22).

This patent anti-flexion apparatus for grinding the revolving flats is applicable to, and can be adapted to, cards of other makes, as a rule, with very little trouble, as well as to the cards of the firm of Dobson & Barlow, who are the makers, but make also other kinds.

They mount the apparatus immediately over the taker-in, in a bracket upon which are formed two surfaces at different levels, to correspond with the angle of the flat. Underneath this fixing, and attached to it, is the grinding roller bracket, both brackets being adjustable in either direction.

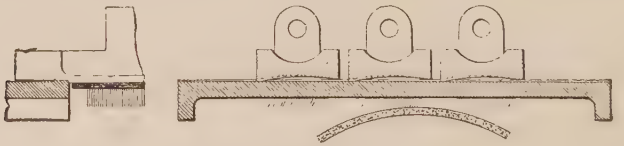


Fig. 23.

Comments on Card Setting.

The adjustment places on a carding engine are (1) between feed plate and licker-in, licker-in to cylinder, mote knives and under casing to licker-in, cylinder to flats, doffer to cylinder, cylinder under casing, doffer comb and flats comb. The settings chiefly centre around the cylinder, and the general law is to set the taker-in, the flats, and the doffer, as close as possible to the cylinder without touching. A gauge of $\frac{7}{1000}$ inch is a reasonably good setting for these positions, although for heavy weights of carding, and the wire not in the best order, this may be sometimes difficult to obtain. On the other hand, a setting $\frac{5}{1000}$ inch is often obtained between doffer and cylinder in fine work. Gauges of the right thickness may be used for these settings, that for the flats being of small size and special shape in order to pass between the flats after one or two flats have been taken out. In one make of carding engine the flexible bend is constructed with suitable apertures for the insertion of a specially long gauge between the wire of the cylinder and flats. Gauge settings may be checked by "ear" setting when the machinery is stopped. The upper extremity of the under casing should go as high up as possible between the cylinder and taker-in, and the setting may be got to 10's or 12's gauge, but

the front extremity of cylinder under casing, nearest the doffer, may be $\frac{1}{4}$ inch or more away, working down to 10's or 12's gauge at the bottom of casing. The mote knives and the face of the feed plate may be set as close as possible without touching the taker-in, or, say, at about 7's gauge. These settings are more especially for Egyptian cotton, and wider settings are often adopted for American cotton. The condition of the machine, the accuracy of grinding, the kind of cotton, the speed of the machine, amount of waste, and the weight of cotton carded per week, are items which may influence the settings more or less. Disturbance of adjustments are perhaps less likely to occur in most cards than formerly as more rigid fixings have been adopted. Some machinists believe in reducing the number of small screws and adjustment places with a view to preventing disturbance of parts. In many cases the doffer pedestals are now very rigidly secured to the card bends as well as the card sides in order to maintain accurate settings. After setting it is well to ring up all nuts as a final precaution. It is advisable to round the flats a second time to see if one adjustment affects another.

One System of Settings in America.

"*Card Settings and Gauges.*—Steel gauges for card setting may be single, 3-leaf, or 4-leaf. The 4-leaf gauges may be $\frac{5}{1000}$, $\frac{7}{1000}$, $\frac{10}{1000}$, and $\frac{12}{1000}$ of an inch thick, respectively. The following settings have been found by long experience to be about right for obtaining a good average of work without risk of facing the wire on fairly heavy production. Gauges may be ground to accuracy, with thickness marked in :—

Doffer from cylinder, $\frac{7}{1000}$-inch tight to gauge.
Flats from cylinder, $\frac{10}{1000}$-inch easy to gauge.
Licker-in from cylinder, $\frac{10}{1000}$-inch tight to gauge.
Feed plate from licker-in, $\frac{12}{1000}$ to $\frac{20}{1000}$-inch.
Licker knives from licker-in, $\frac{12}{1000}$ to $\frac{17}{1000}$-inch.
Cylinder screen from cylinder, $\frac{22}{1000}$-inch.
Back knife plate from cylinder, $\frac{17}{1000}$-inch.
Front knife plate, lower edge from cylinder, $\frac{17}{1000}$-inch."

Front knife plate, top edge or stripping plate, according to amount of stripping required from the flats. This plate is adjustable, to regulate to some extent the weight of strippings to be taken out by the flats. The closer this plate is set to the cylinder, the lighter the strippings, and *vice versa*, to a limited degree.

Card Setting.

Most of the setting points of a revolving flat card are shown in the accompanying sketches. Card setting is a strong factor in

the work of a carder or under carder, being rendered necessary by the grinding away of the wire teeth of cylinder, doffer, and flats, as well as by wear in the chief shafts, disturbance of parts, or defects in the resultant web or sliver.

Setting times vary, but may come every six weeks or so for each card, at any rate for doffer to cylinder, with setting of flats at longer intervals. Before setting: stripping, grinding, and brushing out may be done; belts, bands, covers, and gearing put into condition for easy access by the card setter.

Card gauges are shown in Fig. 24. The flats gauge is of special form as shown in sketch, and whereas the leaf gauge may be straight, and 8 inches or 9 inches long, the flats gauge is a bent steel affair about $2\frac{1}{2} \times 1\frac{1}{4}$ inches $\times \frac{5}{1000}$ to $\frac{12}{1000}$-inch in thickness. Card gauges are specified to be so many thousandths of an inch thick, whereas comber gauges more often have been ruled by the apertures of the wire gauge in regard to thickness.

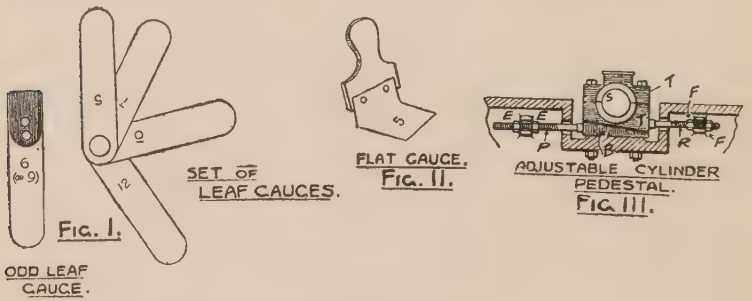


FIG. 24.

For setting the grid beneath the licker-in a quadrant or pointer gauge may be swung from a special shaft placed temporarily in the steps or bearings of the licker-in. For setting flats the flexible bend is the most used method as in Fig. 28, but other methods are preferred by some, such as the well-known inclines of one firm.

Re-setting of many parts of the card becomes necessary chiefly owing to grinding. Also it may be due to disturbance of parts, or a desire to obtain a better carded web or a different amount of waste, e.g. one system is to have the flats re-set in three or four months for heavy grindings and productions (American cotton). Another system is to re-set the flats every six or eight months for light grindings and productions (Egyptian cotton). The doffer and licker is re-set, possibly every three or four months. Apart from any system, an examination of the web, or something wrong with the machine, or a desire for different results may lead to re-setting

of a card at any time. When grinding is finished and setting is required, the grinders may prepare the card by taking away the grinding rollers, brushing the wire out, and adjusting belts and bands.

Gauges.—Figs. I., II. in Fig. 24. (*N.B.*—Letters are used in the diagrams to help a lecture or discussion, but are omitted here to save space.)

Leaf gauges (Fig. 24) are for setting most parts.

The "trowel" gauge (Fig. 24) is for the flats.

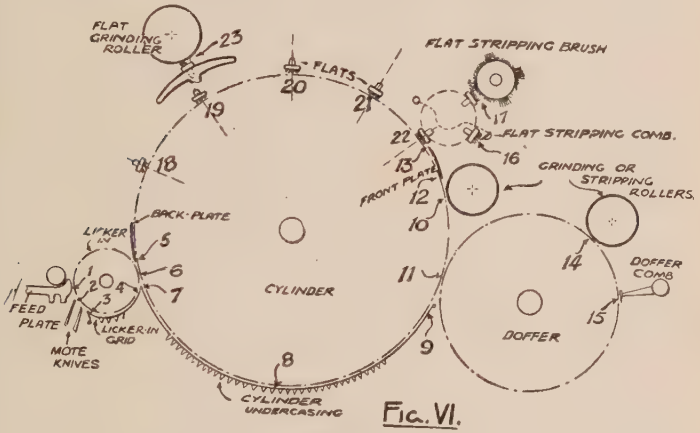


FIG. 25.

List of Settings (Fig. 25):—

1. Feed plate to licker-in.
2. Mote knives to licker-in.
3. Under casing to licker-in.
4. Top edge of under casing.
5. Bottom of back plate.
6. Taker-in to cylinder.

7, 8, 9. Under casing to cylinder.

10, 14. Stripping and grinding roller to cylinder.

11. Doffer to cylinder.

12, 13. Front plate.

15. Doffer comb.

16. Stripping comb to flats.

17. Stripping brush to flats.

18-22. Setting points for flats to cylinder.

23. Grinding bracket for flats.

A precision gauge has lately been introduced to help in obtaining grinding roller settings accurate, also for stripping brushes and burnishers, if required. To help in setting the licker-in under casings, a short radius gauge (Fig. 26) is used. Occasionally a longer radius gauge may be used for testing the concentricity of the flexible bend and the flats with the cylinder.

Cylinder Setting (Fig. 24).—This is only used to a limited extent because moving the cylinder bodily upsets all the adjustments, e.g. cylinder adjustments may help in obtaining true concentricity

of flats and cylinder on a new card and afterwards be used very little unless wearing of the cylinder bearing develops, due to pull of belt or weight of cylinder. Of many devices for cylinder setting, the inclined plane method is most used.

Front Plates (Fig. 26).—There are two front plates making up the space between the flats and doffer (Fig. 26). At D is the cylinder stripping door—set against the card bend BB and suitably hinged. Above the front hinged door is the knife or stripping plate P with a stiffening bar.

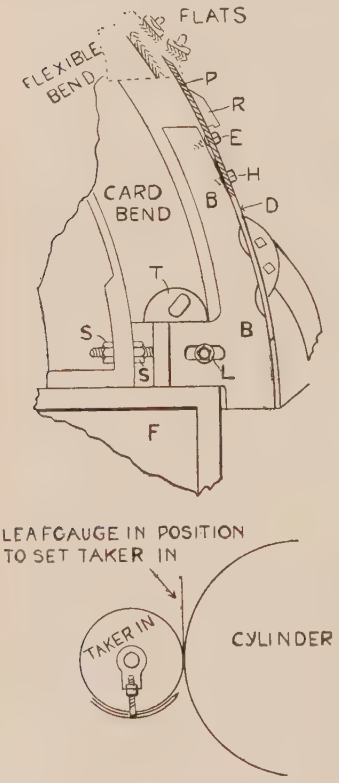


FIG. 26.

Notes.—1. A thin ragged appearance of strips may indicate too close a setting of plate P to cylinder.

2. A dense, heavy continuous web of flat strips may indicate plate too far away.

3. Being thinner at one edge than the other may indicate unequal setting of flats. Occasionally a fixed number of flat strips, say thirty or so, may be carefully weighed to determine if too heavy or light. It is possible for flat strips to be too heavy owing to the back plate being too far away or the cylinder requiring to be ground.

The Taker-in (Fig. 29).—This may be set to $\frac{7}{1000}$-inch. The licker-in teeth should be level and sharp. Use the nuts at AT.

The Feed Plate. (Fig. 29).—The lap roller LR and feed roller H are carried in the feed plate FP so that in setting the face of the feed plate to the taker-in, the two rollers are also moved. FP is set by nuts and screws SS—possibly with an 8's gauge for Egyptian and a 10's for American.

The Doffer (Fig. 27).—If close and level setting of the doffer to cylinder is not obtained, the doffer will not strip the cylinder efficiently and the cotton web may be cloudy. For long staple cotton with card wire in the most level condition we may set to $\frac{5}{1000}$-inch, but $\frac{7}{1000}$-inch is fairly good practice.

The Doffer Comb (Fig. 27).—This may be set for two important

features—viz. distance away from the wire, and the height of stroke in relation to centre of doffer.

Setting of Flats (Fig. 28).—The numbers 1, 2, 3, 4, 5 are the five setting brackets for flats, FB is the flexible bend, PP the pulley for flats, TT the screws to tighten the chain of the flats, and CB is the rigid bend.

To Set Flats. Method 1.—Remove a flat from either side of that particular flat. Use either angle gauge (Fig. 24) or the short leaf gauge (Fig. 24). By means of a special long handle, fitted on the

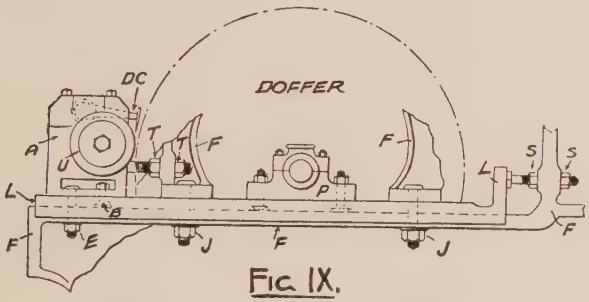


FIG. IX.

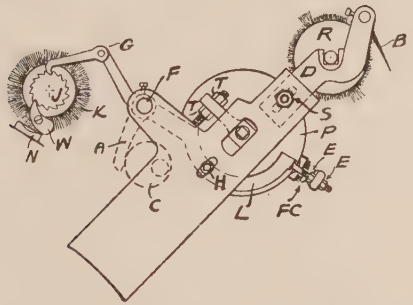


FIG. 27.

shaft of the worm wheel gearing, turn the flat round to each setting point and make the adjustments by the nuts S^1S^2, taking the heel of the flats when setting. After setting one side, set the other side in the same way. The setting should be checked at least a second time since one setting affects another. Both of the centre flat supports No. 3 may be set first, then the one nearest the doffer No. 5, then the one nearest the taker-in No. 1, and finally the two middle supports No. 2 and 4. The flat end should be held down while testing with the gauge.

Method 2.—Choose a different setting flat above each of the five

setting points. Remove a flat from each side of the five setting flats. The flats may now remain in one position during adjustment, and this method may be rather quicker than the other one.

General Table of Settings :—

Feed plate to licker-in	= $\frac{5}{1000}$	to $\frac{12}{1000}$-inch.
Licker-in to cylinder	= $\frac{7}{1000}$	„ $\frac{12}{1000}$ „
Doffer „ „	= $\frac{5}{1000}$	„ $\frac{7}{1000}$ „
Flats „ „	= $\frac{5}{1000}$	„ $\frac{10}{1000}$ „
Flat comb to flats	= $\frac{10}{1000}$	„
Doffer comb to doffer	= $\frac{11}{1000}$	„
Under casing to cylinder front	= $\frac{5}{16}$	„
„ „ „ back	= $\frac{10}{1000}$	„
Mote knives to taker-in	= $\frac{7}{1000}$	„ $\frac{15}{1000}$ „

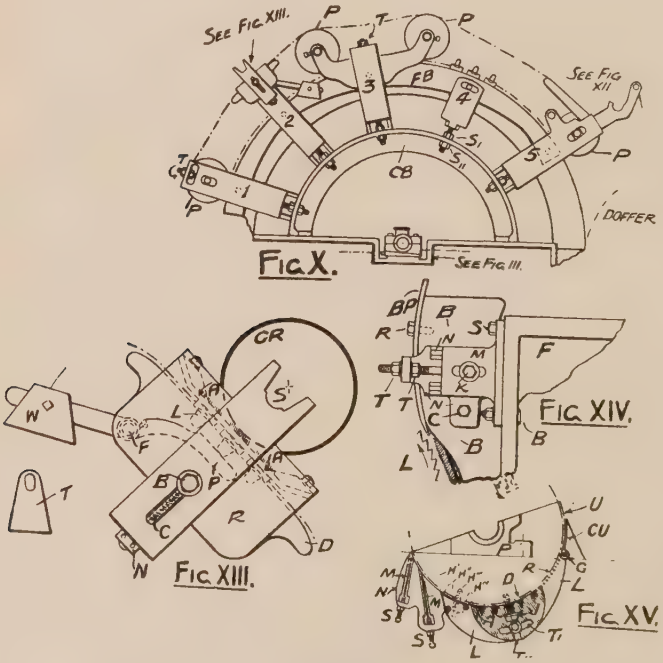


FIG. 28.

Card Questions.—Are the strippings and grindings taking place every time, promptly and efficiently? Are the flats all being kept quite clean? Is the flats comb, or flats brush doing its work efficiently? In what condition is the wire on cylinder, doffer, flats,

and licker-in? Are the settings all to the proper gauges? Is the doffer comb in good sharp condition, properly set, properly speeded, and doing its work effectively, yet running steadily? Is the cylinder rubbing against the card sides? Are all the flats giving approximately the same per cent. of waste? Is the total per cent. of waste as it should be, or the proportion of waste from flats, licker-in, and cylinder? Are there any shiny, or wrongly bent wires? Are the cylinder belt, taker-in belt, and doffer belt of a proper tension? Is the sliver of correct counts? is it reasonably regular in counts? Are the selvedges of the web good? Are any bearings heating as judged by touch? Are the ropes of proper tension, can anything be done to improve the efficiency of any particular card in production or quality?

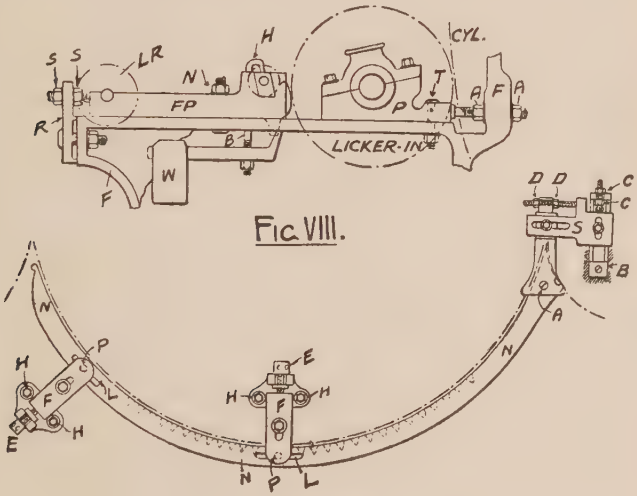


FIG. VIII.

FIG. 29.

In regard to openers and scutchers it has been suggested that better arrangements for removing droppings and waste might be provided, such as using a portable waste box, or at least a floor level and freedom of easily sweeping from under the machines.

To Prepare a Card for Grinding.—When it is desired to subject a card to the ordinary grinding operation the side shaft may be put out of gear so as to run the card bare or empty of cotton, the time required for this running bare depending upon the speed of the flats and other parts, and possibly reaching 25 minutes or so. The cylinder and doffer are then stripped to allow of the cylinder being reversed. During grinding it is the usual practice to reverse the

direction of the cylinder by changing the belt, say, from open to crossed; and if this is done before the flats are run bare the cylinder teeth rub the cotton from the flats into lumps which at once wedge so tightly between cylinder and flats as to stop the rotation of the cylinder. When the card is bare and the cylinder belt reversed the grinding roller may be put in the proper bearings and set up to rub against the cylinder teeth to the extent required as judged by ear and sight, possibly "feel" being used as a preliminary test. A special open belt is used to drive the doffer quickly and directly from the cylinder so as to bring the surface speed of doffer nearly up to that of the cylinder during grinding. From special grooves in the cylinder pulleys, ropes may be used to drive both grinding rollers—one for the cylinder and the other for the doffer. The "dead" roller is sometimes preferred when the wire is in a bad way and requires a great deal of grinding since it operates upon the full width of wire all the time, whereas the Horsfall only operates on a narrow width of fillet at one time. For finishing off, or for all cases in which the most level and the sharpest and most thorough grinding are wanted, the Horsfall is usually preferred.

It may be added that it is customary to strip the cylinder and doffer before applying the grinding roller, as this prevents the cylinder from wedging fast when reversed. Also it prevents dirt and short fibre from blowing about during grinding. If the stripping is not done with reasonable thoroughness, small masses of cotton waste may hang on the teeth and prevent efficient grinding. Often the under casings are brushed the next, as it is a convenient time while the card is empty. Then the card sides are picked and the bearings oiled to allow of easy running.

Emery Filleting.

Emery filleting is now in common use for grinding rollers, and this may be readily applied by any careful and responsible mill man.

The fillet is stored in a dry position and may be simply wrapped round the grinder without applying any kind of cementing material. It is possible to use fillet which does not need damping on application. A grinding machine for flats or rollers may be used for sustaining the grinding roller to be covered, but in any case the roller may be mounted in a pair of suitable steps, a long handle applied to one end of the roller, and one person may turn the roller while a second man carefully applies the fillet and holds it under sufficient tension.

For such fillet slots are provided in each roller end. For a start the fillet end may be secured to the single slot on the left hand of grinder; then the fillet guided and tensioned upon the grinder, and

finally secured to the nearest one of the three end slots on the right hand of grinder. Any overhanging edges may be trimmed off by chisel or file, and then the roller allowed to stand for at least half a day to become properly conditioned and set.

It is better for grinding rollers to be supported in independent racks. Walls are sometimes damp, and standing rollers on end or laying them about may lead to roller or fillet damage.

Grinding Suggestions for Carders.

Messrs. Dronsfield Bros. give the following suggestions for the benefit of carders :—

"1. Always keep your grinders well covered.

"2. A few pence-worth of emery fillet may save £'s-worth of card clothing.

"3. Keep a small stock of emery filleting for emergencies.

"4. Examine the working parts of grinders frequently : guide-forks, differential gears, etc. ; be careful to oil shafts and sockets ; clean out the screw threads, particularly the reversing points.

"5. Never attempt repairs of vital parts, since these are precision tools made by specialists.

"6. In nine cases out of ten, amateur repairs of grinders are a failure.

"7. Keep the grinders in racks when not in use ; don't stand them on their ends.

"8. See to the alignment of the brackets ; otherwise hollow grinding will result.

"9. Grind *light* and *often*, rather than heavy and infrequently ; this is the only way to keep cards up to 'concert pitch.'

"10. If the 'edge' of the emery is gone, replace the emery fillet. Don't take it for granted the emery is all right because it *looks* good. Smooth emery only polishes ; it does not grind carding points.

"11. As long as 'setting' is done by the ear, so long will smooth emery cause damage to the wire.

"12. Broken-out wire, particularly in top flats, is one result of using worn-out emery. The cause of this is 'buckling' through heavy setting, in the attempt to get the right (?) sound of abrasion.

"13. New, sharp emery causes a brisk 'hiss' when in contact ; worn emery has lost this capacity, consequently the operator sets too deep in endeavouring to procure the right (?) sound.

"14. There is probably no accessory in the mill *on which so much depends* as the card-grinding instrument.

"15. It is the *carder's best friend* and ought to be treated as such.

"16. Grades of emery. For hardened and tempered steel wire, use No. 40 and No. 7 ; for mild wire, use No. 6 and No. 5. The first two are fine, the latter two coarse ; these numbers should be used according to counts of card clothing.

"17. Grinders should be balanced so as to run at high speeds.

"18. There are grinders and grinders. The best are, in the end, cheapest; the cheapest are never the best."

Possible Carding Defects.

1. Web hanging or bagging between calender and doffer.
2. Flocks forming at the side of the web.
3. Web following doffer instead of stripping clearly.
4. Flat strips leaving flats in a continuous web instead of being merely joined by a few fibres.

1. In certain definite experiments and alterations the author found that putting doffer comb to make its stroke lower down caused the web to bag or hang down, and if carried to excess broke the web. A remedy might therefore be found in such cases by shortening or lifting the stroke of the comb.

It might happen in some cases that the calender rollers were running too slowly, and, without doubt, speeding them up would tighten the web.

2. It has often happened that flocks, or bunches of fibre, have been formed at the edges of the cylinder and doffer, and some of them have passed forward with the good carded cotton. Often this evil has been due to defects in the construction of the card, and it has been a very difficult matter to provide an effective remedy.

Formerly wooden linings were at the ends of the cylinders, and the replacing of these has diminished the evil of flocking. There has always been a tendency for the emission of fly at the ends of the cylinder, and these have been rubbed into flocks by the end of the cylinder against the lining.

In modern cards flocking is much less prevalent than formerly, due to the great pains taken to provide efficient casings and covers to the ends of the taker-in, cylinder, and doffer. In any case keeping the fly well cleaned from the ends in question will diminish any tendency towards flocking.

3. A remedy for the web following the doffer might be found in setting the doffer comb closer to the doffer, or a little lower down, or in speeding up this comb.

4. As a rule, when the flats leave the cylinder in a continuous web, it is because the top edge of the front plate is set too far away, and in any such case the first thing to be done should be to set this plate closer to the cylinder.

Flats Wrongly Set.

As a matter of fact these parts can scarcely be set too near without absolutely touching, except in the case of very heavy carding.

Actual contact would probably damage the wire more than the

cotton, but the quality of carding would afterwards suffer owing to the damaged wire. Actual contact, or extremely close setting with heavy carding, might cut, break, and nep the fibre.

In the case of the flats being too far away we might expect dirty and cloudy webs, owing to the fibre getting into the toe of the flat, and the flat being so far from the cylinder that the latter could not again take the fibre from the flat in a proper manner, while at the same time the dirt could not be properly transferred from the cylinder to the flats.

The Wellman Card.

Although the Wellman card is now seldom or never made in England, there are some good spinners and practical men who yet consider it to be ahead of the revolving flat card as regards the quality of the work done, without injury to the fibre, at any rate for fine spinning. Stationary flats were used in this card.

Taking the revolving flat card first, it may be said that its great superiority consists in the much larger quantity of work capable of being turned off, combined with a much smaller amount of attention required.

The setting of the flats is far more easily done than on the Wellman, in which each flat requires individual setting. There are far more flats and a great deal more wire capable of being brought into action on the cotton.

The stripping of the flats is performed on the whole in a much better manner than on the Wellman, in which latter card each flat has to be lifted up away from its work, thus leaving a bare place on the cylinder while the flat is being stripped.

The grinding of the flats can also be done without disturbing the flats or stopping the card, which is not practical with the Wellman.

In favour of the Wellman it may be said :—

1. Coarser wire could be used on the back flats than on those towards the front of the card, thus giving a graduated action of the flats.

2. At the same time we may have more bevel or wider setting of the back flats than the front ones.

3. Another important advantage is that the back flats, being dirtier than the front ones, can be stripped more frequently than the front ones, say twice or three times for the back flats to once for the front ones.

In 1900 the author went through a noted fine spinning mill in which all the cards were of the Wellman flat type, but there was little promise of much longer retention.

It may be added that this card is named after its original inventor, viz. George Wellman, of the United States of America.

Three Ways of Increasing Production.

1. Speaking generally, the best and most usual method of increasing the production of the card is to put on a larger Barrow change wheel. This speeds up the doffer and coiler parts at the front of the card, and by means of the side shaft it speeds up the feed and lap rollers at the back of the card.

The beauty of this alteration consists in the counts of lap and sliver remaining unaltered, while the change can be readily effected. The quality of carding would be rather worse.

2. It might happen that our scutchers had already a difficulty in providing sufficient laps for the card, and in such a case it would probably be necessary to increase the thickness of the lap. This would alter the counts of sliver, which is usually undesirable. In cases, however, where we were going upon coarser counts, we might require a thicker sliver, and it would then be probably the best thing to increase the lap thickness.

3. It might happen that we had plenty of laps from the scutcher, and the weight of lap per yard was as heavy as it was considered advisable to have it. At the same time we might desire a coarser sliver owing to coarser counts, or again our draw-frames could take a thicker sliver, but could not conveniently use up more length of sliver. In such cases a larger side shaft change bevel could be put on. The two last changes would give more weight of sliver, but the same length, while the first change would give more length of sliver of the same weight per yard.

Too Much Waste from Cards.

This would, of course, depend upon how and where the waste was being made, which to a large extent would very soon enable a practical carder to localise the cause and remedy the defect. If the under casings of the taker-in were set too far away from the taker-in or from the feed plate, or the mote knives too close, or the feed plate was too far away from the taker-in, we might expect to find too much waste beneath the licker-in. It is possible that the extra waste might be caused by the flat strippings being too heavy, when it is probable that the front stripping plate would be too far away, the remedy being in this, as in the previous cases, very obvious. Occasionally the strips might be too heavy at one side only, when it is probable the front plate would be too far away at that side only of the card. When a card is old, out of truth, and covered with bad wire, it is natural to expect too much waste from these causes. It might be that the extra waste was due to the presence of an excessively large proportion of short fibres in the cotton, and this of course should be borne in mind and attended to.

To Grind a Carding Engine Cylinder (1) *when Newly Clothed,* (2) *After Ordinary Wear.*

When intending to grind a card, the feed should be stopped and the card run thoroughly bare, this operation taking anything from half an hour to an hour, according to the speed of the card. As the flats are ground in position with the card working, reference is now made to the cylinder and doffer. The covers for these are removed so as to expose the wire to the action of the grinding rollers. There are differences of opinion as to the use of the Horsfall, or the full length grinding roller, some men preferring to use the latter first, but finishing off with the former. The cylinder must be reversed in direction during grinding, as it would be difficult to get enough difference in surface speed between the grinding roller and the cylinder if both went the same way. The doffer, of course, is not compelled to have any such reversal, as it always, during working, revolves the contrary way to the setting of its teeth. It is a matter of opinion as to whether slow or fast grinding is the

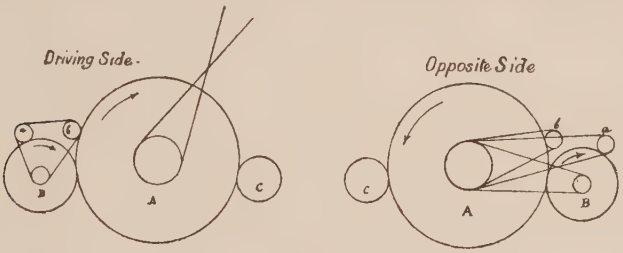


FIG. 30.

better, and the practice is therefore subject to variation in this respect. Slow grinding, however, is not much used. It may just be remarked that in slow grinding the speeds of the cylinder and doffer are much reduced, while in ordinary grinding the cylinder remains at its working speed, and the doffer is speeded up. As regards the difference between grinding a new card and a card that has been working for some time, in the case of the former there would, of course, be no necessity for running the card bare, as the cylinder, flats, doffer, etc., would not be charged with cotton. In the natural order of things it would take longer to reduce the wire of the new card to a satisfactory condition, and this would necessitate a longer time of grinding. In either case the requisite cords or belts would have to be applied for driving the cylinder and doffer and the two grinding rollers.

Fig. 30 shows a card set out for grinding. A is the cylinder driven by the crossed belt, and revolving during grinding upwards from the doffer. An open belt on one side of the card gives motion

to the doffer, B, and on the same side two cords give motion to the grinding rollers, *a*, *b*. It is presumed that Horsfall grinders are being used with pulleys on each end. The opposite figure shows the driving of the pulleys on the other ends of the rollers by means of a triangularly disposed belt. Most Horsfalls only need a pulley at one end.

Grinding.

Emery.—Emery is well established as the best material for grinding card wire, although rival materials have often been tried, such as flint, carborundum, and corundum, which are harder but less suitable for card wire of either mild or hard steel. Emery is neither too hard nor too soft for the purpose and is well established as the best medium.

Round or flat emery is not recommended, the best emery being pyramidical or angular in form.

When examination of the emery, or of its grinding results on wire and web, disclose that the emery has lost most of its efficiency, such smooth, worn emery should be promptly replaced.

Setting the emery too heavy on may lead to broken-out teeth and hooked wires.

Hand Strickles.—The old hand strickles are practically out of use in ordinary cotton carding, but in a modified form are occasionally used for roller and clearer cards, treating cotton waste.

Formerly some carders and leading grinders were expert in using hand strickles, but the clouds of raised dust and short fibre always made the work of bending over a card to use the strickle extremely unhealthy, and it is doubtful if many carders would now use these strickles with much skill. An ordinary wood strickle may be about $1\frac{1}{2}$ feet long × $3\frac{1}{2}$ inches wide, sometimes having back handles, and in other cases with corrugated or fluted edges for gripping purposes.

The self-acting strickle grinder was a later development, being traversed by a long screw, before giving place to its successor, the modern Horsfall.

Manipulation of Coloured Cotton.

Coloured cottons may be divided into two broad classes—those possessing a natural tint, and those that are dyed artificially.

Coconada Indian and Red Peruvian have always been quoted as extreme examples of naturally coloured cotton, while Brown Egyptian has had a sufficiently distinctive colour to vastly affect its practical working and its subsequent uses; but has never been so strongly marked as to come under specific classification as a coloured cotton.

Cotton will take dye in almost any stage of its conversion from

the raw state to the finished yarn or finished woven or knitted garment.

The present note refers more especially to cotton coloured in the raw or first stage, and it is usual for coloured cotton to be somewhat more troublesome to clean, open, card, and draft, than cotton in the natural white or slightly tinted condition.

The preparation system of working is preferable for some sorts of coloured cotton, especially when intended for any kind of warp yarn in which strength rather than softness is wanted.

Small roller drafts at the single passage of fly-frame that is used, and also at the spinning machine, with draw-frames excluded, are recommended for such cases. Also the roller and clearer card in preference to the revolving flat.

The condenser system pure and simple may be used for coloured cotton intended for wefts. Coloured raw cotton does not find much vogue for the finer yarns and better class cottons, dyeing at some later stage being preferred. When working rather low classes of coloured cotton, or plain cotton waste on the revolving flat card, the card may have a "fancy" roller fitted beneath the licker-in and allowed to run a week without cylinder stripping. The author has had practical experience of such cards, and prefers the roller and clearer for cotton waste, or coloured cotton.

Double carding on the roller and clearer principle, with the Derby doubler coming between breaker and finisher cards, are recommended for coloured cotton, the finisher card filling four or six sliver cans at one time, with very thin slivers; afterwards the slubber and the mule with three lines of small diameter rollers. The fancy roller on a card has a surface speed one-fifth or one-sixth faster than that of the cylinder. It has long teeth, whose back points may very slightly penetrate those of the cylinder in order to entice the cotton fibres upwards and thus obtain more perfect doffing action.

The finisher roller and clearer card which is served with laps from Derby doubler does a great amount of doubling work on the cotton, and this of itself is always a most excellent thing, but is of still more pronounced value when no draw-frames are used.

Coloured cotton is often worked on revolving flat cards, but the writer in such cases strongly advises the use of comparatively good cotton, containing a minimum amount of very short fibre or waste.

Coloured cotton is often difficult to operate, but becomes easier when short roller drafts are used and when roller draftings are used as little as possible; although this means the spinning of low counts of yarn. When coloured cotton becomes soft with opening, cleaning, and drafting, the fibres are affected by the slightest of air currents, and apparently lose that natural affinity for each other

which is so useful in mill processes. Waste is more easily produced.

An intermediate frame may have the creel removed and set out to operate from sliver cans like a slubber. Coloured cotton should be well twisted at the fly-frame.

The colour of the cotton is somewhat affected by the amount of twist, a darker shade resulting from increased twist. Reckless alterations in amount of twist, or very slack and greasy spindle bands, will affect colour in the cloth.

When ordinary salt has been used considerably in dyeing the cotton, the material is liable to become sticky in damp weather or a very humid atmosphere.

When two colours are required to be definitely twisted together it may be done by using double roving at the spinning machine—either continuous or intermittent—and putting together a bobbin of either colour. Instead of this, in some cases a second bobbin and fly-frame is used and a bobbin of either colour put up together at this machine, leaving single roving at the spinning machine. In the U.S.A. there are five or six times as many ring-frame spindles as there are mule spindles, but these conditions are reversed in England. In either case the mule is a good machine for coloured cotton or cotton waste of moderate quality.

In putting together two bobbins of different colours behind a fly-frame or spinning machine, it is also sometimes the custom to have two different counts.

The resultant counts are found by the following rule :—

$$\frac{\text{The product of the two counts}}{\text{The sum of the two counts}}.$$

Unequal counts worked in this manner add to the difficulty of getting accurate results.

The rollers may grip the coarser roving more firmly than the finer one, and to remedy this as much as possible the thicker material should be twisted as softly as possible to allow it to spread out as much as possible. Careful operatives are needed to prevent "single" when working two coloured rovings in this manner.

For cheap goods sometimes an extra licker-in has been fitted to a roller and clearer card, working on the manifold coiler system, and a production of 250 lb. per week of forty-eight hours obtained per card. At the one passage of fly-frame a $1\frac{1}{4}$-hank bobbin is produced, and this made into yarns as high as 8's or 9's at the spinning machine.

The condenser system gives the maximum woolly, full, or soft feel to cloths, while the preparation system gives a firmer, smoother, and stronger effect.

In one part of the world or another, yarns from coloured cotton

have been more or less used in certain classes of shirtings, ginghams, domets, cottonades, and sponge cloths.

Carding (Ure, 1836).

"The cylinder cards invented by Lewis Paul, and patented in 1748 were covered parallelly to the axis with fillets of leather, wire mounted, having intervening strips free from points.

"About 1760 cylinder cards were applied to cotton in Lancashire, Mr. Peel being one of the first Lancashire spinners to adopt the same, and employing James Hargreaves, the inventor of the jenny, to do this work.

"About 1780 Arkwright took up the cylinder card and made it into a practicable machine, a feed-apron, stationary flats, a crank-comb for stripping the doffer, and a driving connection between feed and delivery being established. An original Arkwright carding engine forms part of the collection in Chadwick Museum at Bolton. This card in Arkwright's time did practically the same kind of work in much the same manner as at present, the modern machines, of course, containing all sorts of detailed improvements." The revolving flats of Evan Leigh have long since displaced the stationary flats of Arkwright's card.

Cylinders.

Ure says: "In many factories the cylinders are not constructed of wood, with iron framing, but are made entirely of cast iron, and are coated with a cement composed of chalk and glue, which is somewhat harder than plaster of Paris. Into holes drilled into the iron cylinders, wooden pegs are fixed for receiving the mails or pins which are used to fasten on the sheet or fillet card leathers.

"In many of the coarse spinning, and in all of the fine spinning, two sets of cards are employed, called the breakers and finishers, which do not differ in any essential respect, except in the fineness of the card teeth. The card overlooker is called a '*stripper*' when he cleans the card teeth from the entangled filaments."

The Traversing Emery Wheel Grinder.

For a good many years this contained a pulley at one end for driving the long screw, and a second pulley at the other end for driving the long tube.

The more modern method is to have a pulley at one end only, on the long, slotted tube. At the other end a differential motion of special construction drives the double-way screw at a fixed rate of speed from the steel tube of 3 inches diameter. While this fixes the proportionate lateral traverse within limits, it carries the two material advantages of (*a*) preventing wrong side traverse speeds

by foolish alteration of pulleys—an effect sometimes noted by the author. (*b*) It only needs one driving cord or belt.

There are now several makes of differential motion for traversing emery grinding rollers, but probably the best known is that of Messrs. Dronsfield. For grinding cylinders and doffers this has a pinion of thirty-five teeth gearing with the internal gear box containing forty teeth. The pinion obtains its rotation from the socketed end of the tube, upon which the whole of the motion is mounted excepting the gear box.

The gear box is fixed to the screw shaft, and thus the screw is driven through the motion from the tube at the reduced speed of 40/35, or one revolution on every 8. The emery wheel grinder of any make and any drive has always depended for lateral traverse upon difference in speed between screw and steel tube, as well as pitch of screw. The 35/40 standard has done so well that the firm have made it a standard, although other speeds could be adopted within limits.

These conditions give a lateral traverse of possibly 150 inches per minute, at about 750 r.p.m., this being equal to about three traverses per minute across the width of the card, single traverses.

Nowadays, there is practically unanimous opinion that for cylinders and doffers the traversing emery grinder or so-called Horsfall is the best grinding instrument. There is some little argument in regard to the flats owing to the speed of flats taking one end of a flat away while the other end is being ground.

The traversing grinder gives less waste in grinding wire away, it gives more level and parallel grinding and sharper wire points than the long grinder, although the latter possesses advantages for heavier and rougher work.

In "preparation" spinning and "condenser" spinning, the full-length grinding roller is often preferred for the coarser wire and rougher work, usually associated with the carding of cotton waste on the roller and clearer card. With the Horsfall the same emery touches all portions of wire and acts well on the sides. Hollow grinding of cylinders is more likely to result from the full-length grinder, and although Rothwell's traversing emery wheel grinder contained a screw with a wider pitch in the centre to prevent hollow grinding, this device has not been deemed necessary by many people.

With the Horsfall the wire is only deflected sideways for a short time and then straightens again, whereas with the full-length roller the wire is practically never free and is more likely to get hot.

Grinding of Flats.—It is the opinion of many practical men that even for revolving flats the Horsfall or traversing side grinder is genuinely better than the full-length roller. The slight bending of wire for a very short period only, and the frequent approach of

emery wheel to the wire from each side alternately, conduce to sharper, straighter, and cleaner wire points.

It has been recommended that the traversing emery wheel grinder should make about six traverses per minute when grinding flats, as against three per minute when grinding cylinders and doffers, the quicker speed compensating for the slow forward movement of the flats.

For this quicker speed Dronsfields may use a 38/50 differential combination, as against the 35/40 for the cylinder traverse.

The rotation of emery wheel should be at least as fast for flats as for cylinders, and still faster would probably be better, as there is a reverse revolution of cylinder for grinding but not of flats.

Modern carding engines provide grinder brackets which permit the traversing grinder to travel clear off the end of the wire at each end of flats, cylinder, and doffer. If the grinding brackets are faulty in this respect it is possible to have traversing grinders which permit a momentary well at each end so as to give as much grinding effect at the ends as elsewhere.

Flats are slowly moved and are connected by means of a separate chain on each side of the card. These chains stretch out longer in working, and means are provided for tightening. Unequal elongation in chain may lead to unequal grinding.

Operative Grinder's Work.—It is quite possible that better carding would be obtained if stripping were confined to one set of operatives and grinding to a different set—especially since the extensive adoption of vacuum stripping. Grinders might then be given more time to do the work, have the chance to become really careful and skilful in setting the rollers and doing the work generally. Frequent grinding with rollers lightly set to the wire is generally considered best, but the setting should neither be too light nor too heavy. Heavy grinding may result in "barbs," "hooks," and soft wire owing to over-heating of the wire.

"Topping" and "polishing" only may be caused if the setting is so light as not to produce necessary "hiss." On the other hand, "sparking" due to heavy setting is undesirable.

Slow running of cylinders and doffers for grinding purposes has not met with much favour, and cylinders at working speeds, with doffers at about double the cylinder speed, say about 170 and 340 r.p.m. respectively, is the standard practice.

Seven inches has become a much used standard diameter for both emery wheels of 3½ inches width and also full-length grinding rollers, with r.p.m. of possibly 650, a little more or less as may be. On independent grinding machines a larger roller diameter is used, sometimes 12 inches. Defective grinding will result if the grinding brackets are out of truth either vertically or horizontally. Makers

of grinding rollers are usually ready to fetch away such rollers for expert machine shop testing in regard to precision.

Separate Grinding Machine for Flats.—Many people use the full-length grinder for the flats. Some of these finish off with the Horsfall and some use the Horsfall almost entirely.

For the very best results some firms have adopted the custom of taking the flats entirely away from the card, timing the system so that each set of flats may be treated at a separate grinding machine, perhaps once per annum, and this in spite of the general use of patent flat-grinding motions to grind flats on the card from their working surfaces.

Dronsfield's separate machine is termed "the automatic flat grinding machine, with flat tester."

Many people yet do all their flat grinding on the card itself and refuse to be at the trouble of pulling flats out, grinding them in a position removed from the card on a separate machine, and replacing on the card.

Difficulties which arise in grinding the flats on the card are (*a*) irregularity in wear in the working surfaces of the flats, and a deflection of flats, a card having about 106 separate flats, some lack of stiffness and rigidity during grinding.

The separate grinding machine grinds the flats with their bevelled and milled working edges or bearings resting in suitable seating plates. They are ground in carding position. The grinding action on each flat is very noticeable. The flats are readily tested.

In a mill containing 100 cards there may be two cards per week in which the flats are so treated. At the same time the card may receive an extra cleaning and some special re-setting and overhauling. In some cases a spare set of flats is kept for each card stopped. In other cases it is found possible to have two cards in 100 stopped a week or so at a time.

The system has been tried of having a few dummy flats and taking a few flats out at a time, with the dummy flats on the card for the required time.

The flats are ground as required on the card in between the annual separate grindings.

Dronsfield's separate machine for grinding flats operates upon three flats at one time. It is fitted with automatic feed motion and stopping motion to save labour and time.

The Licker-in.

The metallic taker-in is almost universal for ordinary cotton cards, being more powerful in its cleaning effect, more rigid and durable in the wire, than the leather or cloth foundation.

It has been customary to send a damaged metallic taker-in, or

one that needs re-covering, to a machine shop for the necessary repair.

The taker-in is one of the most important organs of the card, and does a full share in the opening and cleaning of the cotton.

To get the best from a taker-in, its teeth should be sharp and erect, and this organ should be as cylindrical and should set as parallel to the feed roller and cylinder, as may be conveniently possible. There are small repair shops which specialise in re-covering licker-ins. Unfortunately, blunt and bent teeth, and want of parallelism often result in the taker-in, due to the comparatively heavy work required from it, as it may be described as the beater of a carding engine.

Messrs. Dronsfield have devised a special machine and special tools by means of which a taker-in may receive special grinding and tooth-dressing at a spinning mill. The machine is designed for dressing and straightening up bent teeth, re-pointing the teeth, and for grinding parallel and cylindrical all kinds of rollers covered with " saw-tooth " wire.

The licker-in is removed from the card and placed in the special pedestals of the machine referred to and is rotated at the required speed. There is a tool carriage which sustains the dressing or aligning tool, and enables this tool to traverse the length of licker-in. The tool consists of a number of hardened and tempered steel ploughs or blades which fit between the spaces of the wire setting. A traversing emery wheel will afterwards do the grinding.

Faulty Working of Carding Engine in Regard to—

(*a*) Strips leaving flats in a continuous fleece.
(*b*) Web leaving doffer irregularly.
(*c*) Web hanging between doffer and calenders.

(*a*) In regard to strips leaving flats continuously, the first consideration is the adjustment of the front plate, and as a rule it will be found that setting this plate nearer the cylinder will diminish the weight of flat strips. If this does not follow there is probably something wrong with the plate itself or its adjustment. The setting of the back plate, the speed of the flats, and the condition of the wire may also exercise some effect on this problem.

(*b*) If the web leaves the doffer irregularly, and yet the back lap is good and the cotton reaches the doffer in a satisfactory condition, then it is probable something is wrong with the doffer comb itself. For example, it may be advisable to set this comb a little closer to the doffer, or a little more accurately in relation to the horizontal centre line of the doffer, or the points of the comb may need straightening, cleaning, and polishing. In more extreme cases a higher speed of doffer comb may prove a remedy, and certainly

the tension of the rope or ropes for driving this comb should be properly regulated. The condition of the wire on the doffer itself might exercise an effect on this problem.

(*c*) There is some connection between this fault and the preceding one, and it is by no means unlikely that a remedy for one evil would also prove a remedy for the other one.

Altering the height of the doffer comb in relation to the horizontal centre—as for example lifting the stroke of the comb—has often proved a remedy for web hanging down between doffer and calender. There is usually a slight draft between the doffer and calender, and it would be as well for the amount of this draft to be definitely ascertained to see if correct.

Card Strips.

If the strips as a whole are too heavy, there are three or four very possible causes. The upper edge of the front plate may be too open or too widely set, and may be put somewhat closer. Occasions have arisen in which a diminution in weight of strips has been provided by closing in the back plate somewhat. As regards the total weight of strips obtained in a certain time—as distinct from the weight of individual strips—this may be reduced by a slower speed of flats. Strips being heavier in some flats than others may be due to the bearings or working ends of some flats being worn more than others and giving a somewhat different heeling or setting to those flats; or to the wire being in better condition on some flats than others. Badly stripping flats have often been a source of trouble, and may be remedied by such things as the following according to the requirements of any particular case: using a better or an improved stripping brush such as Philipson's combination; running an ordinary stripping brush quickly for a short time; sprinkling the flats with French chalk, or possibly in very extreme cases finely powdered blacklead, although this dirties the cotton; burnishing brush; a better adjustment of the stripping brush or of the flats stripping comb; grinding the wire to a better point. Improved forms of flats comb have often done good especially in cards in which the flat chains have worn.

Card Stripping.

An ordinary stripping roller may be made of well-seasoned pine wood which is most unlikely to split or warp. It should be as light as possible consistent with the required strength. It is probably best when the pine wood is mounted in lag form upon iron blocks keyed upon a steel shaft. The hardened and tempered steel filleting should be bent and point forward in the direction of rotation, and may penetrate the card wire teeth possibly $\frac{1}{8}$ inch, and it

cannot reach below the bend or knee of the wire without danger of plucking and damaging the same. The object of stripping is to clean fibre, leaf, portions of seed, dust, or other impurities out of the card teeth and may take place from two to four times per day as desired.

Removal of Stripping Dust.

The British Factory Act now demands the use of apparatus which shall immediately and effectively remove the dust and refuse released by the stripping operation; and there is now a choice of effective apparatus for the purpose.

As a rule a hood extends across the width of the card between the cylinder and doffer, and is connected by pipes to either fans or pumps which draw away the refuse as released by the stripping brush. Cook's automatic vacuum stripper dispenses with the stripping brushes and couples directly up to the cylinder or doffer, and is automatically traversed across the width of the card.

Whatever apparatus is employed the effective and prompt removal of the dust represents a very fine improvement in preventing lung affections, bronchitis, and asthma, by prompt removal of the fine dust and short fibre. It is one of the present author's earliest mill recollections that carders and grinders were frequently troubled with chest, nose, and throat affections: and were regularly wearing ready-made cotton respirators, chewing tobacco, or taking snuff, as a less evil than absorbing stripping refuse into the bodily system.

In regard to cylinder and doffer, any hood or partial covering which may be deemed necessary for the stripping roller should be of the minimum weight, consistent with required strength.

Stripping of Flats.—Somewhat different conditions are introduced in connection with the stripping of the flats, in which case there is continuous and automatic stripping, and very little dust or fly is liberated into the atmosphere. The brush remains in one position and is aided in its work by the preliminary action of a flats comb.

Combs for Flats.—There are now various patented forms of both combs and brushes for stripping and cleaning the flats, and it may be said that the general results are now much more satisfactory than formerly, either for mild steel or hard steel wire. In some forms of comb the comb recedes from the flats on the return stroke and comes towards them on the acting or down stroke. In one good arrangement the comb is held forward by a spring action which keeps the comb pressing forward to agree with each flat as it comes along. Special arrangements of the star driving wheel of flats prevent the flats from hanging forward into the comb when the flats chains become elongated.

Brushes for Flats.—As regards the flats stripping brush Philipson's brush has received very extended adoption, and has done

excellent service, although much dearer than an ordinary plain spiral bristle roller. Philipson's brush consists of two rows of wire teeth, and two narrower rows of bristles coming between these wires. The roller is run very slowly, to prevent stripping wire damaging card wire, the bristles penetrate the flats teeth more deeply than the wire teeth, and a special hand stripping rail is applied for cleaning the stripper.

When flats have become felted with seed, short fibre, and refuse, it has been found difficult to clean them with an ordinary spiral bristle brush or even a burnishing brush, although good has often been done by running these organs very quickly for some little time.

The best modern flats combs and stripping brushes greatly restrict felting of flats and the tedious operation of hand picking of flats.

Rhode's self-clearing flat cleaner is of somewhat more recent date than Philipson's, and has been adopted with advantage in some cases. The Philipson brush is often applied to every card, whereas the makers have recommended Rhode's stripper as a portable combination for temporary application in cases of felted flats, and have contended against the full-time use of wire for stripping purposes. Rhode's stripping roller may revolve at 30 to 40 r.p.m., the wire brush roller set $\frac{1}{16}$ inch deep to start with, and gradually set a little deeper during the one to two days' use, which may be needed for felted flats.

Rhode's stripper is a combination arrangement. There is a central driving shaft, a spiral bristle roller, a wire-covered stripping roller, and a circular comb which collects the fibre and refuse from the aforesaid two brushes while at work. There are also revolving end discs for driving the small rollers specified.

Placed temporarily in the same steps as the ordinary flats brush, it may be driven by the same rope and pulley. The rotation of the small brush rollers and comb is duplicate, since they not only revolve around the central shaft, but they also rotate on their own axes, after the style of the carrier wheels of the sun and planet motion for fly-frames.

The net result is a combined picking and sweeping action which operates effectively on felted flats without injury to the foundation or the flats wire itself. The bristle brush penetrates the flats wire deeper than the wire, as in Philipson's stripper. The wire attacks and loosens the felted fibre and refuse, the bristle roller extracts the same, and the comb collects it.

Burnishing.

Formerly unknown, burnishing became more or less extensively used about 1895 to 1905, although never in favour with some practical men. The wire may be as long as stripping wire but

straight and hard. The very name identifies it as a polisher of wire rather than for stripping the refuse from the card teeth.

In some cases burnishing may occasionally do good work in removing dust, fibre, or other undesirable matter from the card teeth of flats, but if burnishing is excessively and recklessly performed it may polish card teeth so much they will loose their carrying power on the cotton fibres. If wire is barbed and spoiled by recklessly setting too close, burnishing may help to get the card teeth up again.

Neither burnishing roller nor stripping roller should touch the cloth foundation of the card wire, or the cloth will be raised so much it will tend to stick to the cotton fibre.

There are some who contend if the burnisher is used at all it should be before grinding, while others contend that burnishing should follow grinding.

Card Cylinder Painting.

A good many years ago it was the invariable practice to paint all cylinders and doffers before covering, and also to apply a layer of thin cloth before wrapping on the filleting. Later on, the painting and cloth covering were entirely and very generally discarded for the double reason that it was considered that the oil in the paint helped to rot the foundation of the card clothing, and also the special layer of cloth prevented absolute accuracy in grinding and setting. The reasons for the original use of paint and cloth were : (*a*) to obtain a good, firm bedding, and (*b*) fixing for the filleting so that side slip should be prevented. After years of clothing cylinders upon an absolutely bare, smooth, and slippery surface, it has been considered that side slip and blistering have resulted in some cases from this custom. Hence it is now quite common to paint the bare iron of the cylinder with a paint free from oil, and which may consist, for example, of turpentine and gold size, but not used with the extra layer of cloth. Oil in the paint is to be avoided.

Slow motion grinding of cylinder and doffer is very seldom done in England—except in some cases for new carding engines—because it is more troublesome, and requires longer time than slow grinding. Moreover, most people consider it more accurate to grind the cylinder at its ordinary working speed owing to the effects of such features as centrifugal force.

Good Carding.

Given a well-set-up card, it would then be first advisable to provide it with well-made laps of cotton, properly opened and cleaned in the blow-room, in order to get a satisfactory sliver in good quantities. Attention to drawing the fly, keeping the front ends pieced up, not allowing lap licking or lap slipping to occur,

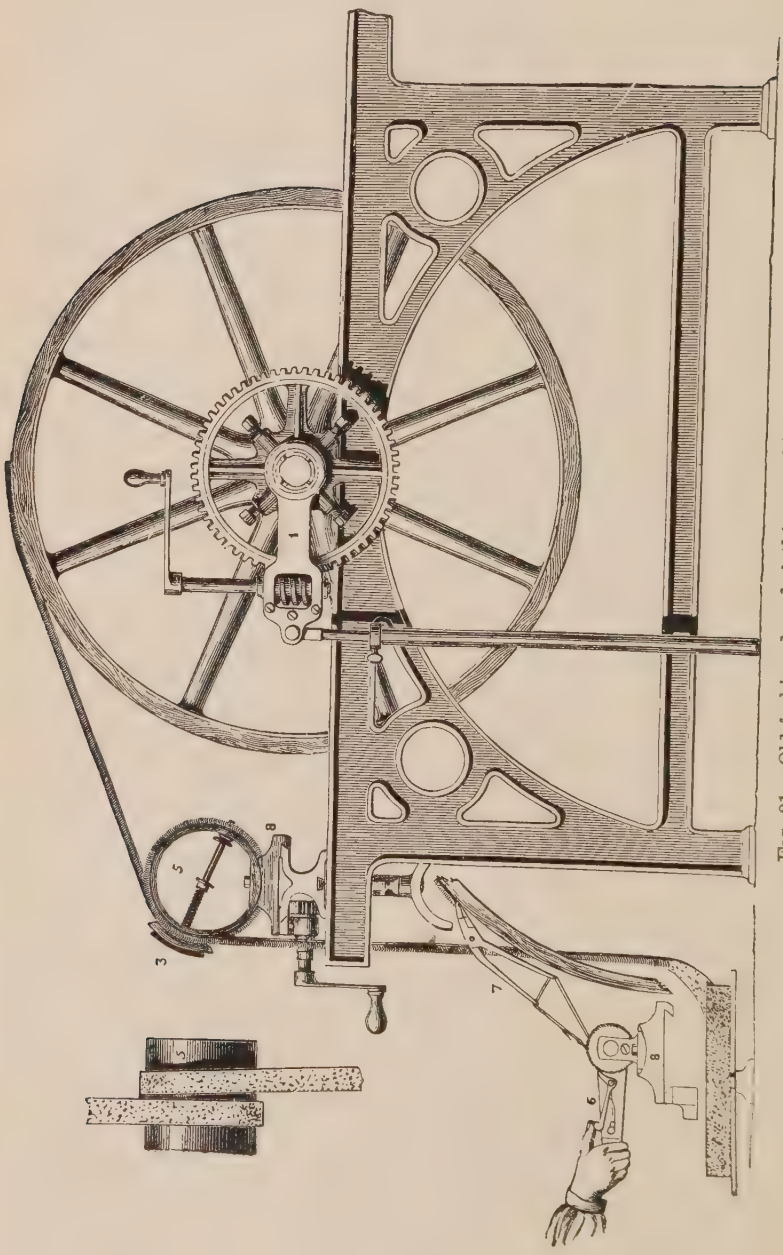


FIG. 31.—Old-fashioned card clothing machine.

ordinary cleaning and oiling, and proper changing of the cans, will all facilitate the production of satisfactory work from the card. It goes without saying that strict, careful, and regular attendance to stripping, grinding, and setting are essentials in the production of good work from a card. Broken, hooked, and other damaged wire should be attended to as soon as possible, and we should be sure that our total and intermediate drafts in the card are of right proportion, and belts and bands of proper tension. The number of stripping and grinding times varies considerably with different firms and different cottons. For Egyptian and American cotton many firms strip cylinders three times daily and doffers twice. For Indian cotton stripping may occur possibly more per day. With hardened and tempered steel wire a light grinding once a week is often done, but a period of two to four weeks sometimes elapses between grinding times, and then probably heavier grinding is required. There have been many occasions in which the grinding of hardened and tempered steel wire has only occurred at much longer intervals than above mentioned. These points are affected by the working hours per week.

Carding of Egyptian and American Cotton.

The cylinder speed is usually rather higher for American than Egyptian, say, average about 170 r.p.m. for American, and 160 to 165 for the finer cotton. The card clothing is rather closer and finer for the Egyptian, say, 110's or 120's counts of clothing on the cylinder, and 120's or 130's for the flats and doffer, while for the American it is usual to put on about 10 counts lower or coarser in each case. It is usual to run the doffer faster for the American than the Egyptian, and this permits a greater proportion of cleaning for the finer cotton as required for the higher quality of yarn. Perhaps even more does this remark apply to the feed and lap rollers owing to the greater draft usually put in the cord on Egyptian cotton. Front calender and coiler speeds are regulated by the doffer speed. It is customary to move the flats faster for the finer cotton, say, $3\frac{1}{2}$ inches per minute or so, as compared with possibly 2 inches or so for American, and this is the chief factor in the extraction of more waste from the Egyptian cotton than the American. Rather closer settings of the principal organs rule for the Egyptian, and this gives rather more cleaning and rather more and better waste.

Card Clothing.

Card clothing consists essentially of two fundamental parts viz. the wire teeth and the foundation or base in which the teeth are secured. Both these items have been subjected to a good deal of experiment and practical experience in order to determine the

best features. Card clothing is not an item in which benefit is derived from using cheap and low qualities. Mild steel wire is now only used to a moderate extent, the usual practice being to employ hardened and tempered steel wire, which is stronger, much more durable, and keeps a sharp point longer. It is necessary for card clothing to be firm, yet elastic in regard to the foundation, to have wire of a proved good working shape or section, for the wire to have the right amount or "keen" or forward inclination, and to be of well-defined uniform thickness and temper, of correct length of tooth, and to be correctly inserted in the foundation. For flats and doffers probably a cotton, wool, cotton foundation is most used, possessing the required strength, good holding capacity for the wire teeth, and yet with sufficient flexibility for wrapping neatly upon the doffer and a reasonable amount of elasticity for the wire. To increase the elasticity effect it is a common practice to put a facing or very thin layer of rubber on the top of the cloth foundation when intended for the cylinders, except in very hot countries. The card setting machine which cuts off the wire, bends each small piece into two teeth united by the crown, and then inserts each pair of teeth into the cloth foundation, is really a very wonderful machine, and does the work with great accuracy and rapidity. Card clothing must possess good carrying effect on the cotton, permit the waste and dirt to be readily removed by the stripping operation, enable the cotton to be transferred from one working organ to another, and be convenient for re-grinding as often as may be deemed advisable. There can be no doubt that improved card clothing, combined with greater truth in the card surfaces, have materially helped in the great productions of modern cards.

Waste in Carding.

The first place at which impurities and waste are removed is beneath the licker-in. The licker-in is the beater of the card, and drives out a fair amount of any leaf, portions of seed or other undesirable matter that have escaped the blow-room machinery. The use of improved licker-in under casings has tended to reduce the amount of fibrous waste taken out at this point while yet getting out the other wastes. In some cards a good deal of fibre is found in the licker-in fly, while very little fly is found in other machines. The flat strips may be mentioned next, and these frequently account for more waste than any other part of the machine. This waste is usually of a good usable class, containing a large proportion of fibre, some of which is quite long. This is so true that many firms now use up their flat strips in one way or another instead of selling them. In England the flat strips are delivered over the doffer, being continuously and automatically cleaned from the flats by a special comb, followed by a revolving brush to perfect the cleaning.

The strips from cylinder and doffer may be removed three or four times per day, the card being stopped for the purpose, and these strips also contain a good deal of usable fibre, mixed up with leaf, stick, and motes. A small amount of fly is gathered from beneath the cylinder.

Defective Working of Carding Engines.

(*a*) In regard to strips leaving flats continuously, the first consideration is the adjustment of the front plate, and as a rule it will be found that setting this plate nearer the cylinder will diminish the weight of flat strips. If this does not follow there is probably something wrong with the plate itself or its adjustment. The setting of the back plate, the speed of the flats, and the condition of the wire may also exercise some effect on this problem.

(*b*) If the web leaves the doffer irregularly, and yet the back lap is good and the cotton reaches the doffer in a satisfactory condition, then it is probable something is wrong with the doffer comb itself. For example, it may be advisable to set this comb a little closer to the doffer, or a little more accurately in relation to the horizontal centre line of the doffer, or the points of the comb may need straightening, cleaning, and polishing. In more extreme cases a higher speed of doffer comb may prove a remedy, and certainly the tension of the rope or ropes for driving this comb should be properly regulated. The condition of the wire on the doffer itself might exercise an effect on this problem.

(*c*) There is some connection between this fault and the preceding one, and it is by no means unlikely that a remedy for one evil would also prove a remedy for the other one.

Altering the height of the doffer comb in relation to the horizontal centre—as for example, lifting the stroke of the comb—has often proved a remedy for web hanging down between doffer and calender. There is usually a slight draft between the doffer and calender, and it would be as well for the amount of this draft to be definitely ascertained to see if correct.

The Card Web.

Sagging of the web may result from dirty trumpets, or waste accumulating at the ends of the top calender and hindering its rotation. A slight sagging of the web is advisable rather than a tensioning effect.

If there is too much slacking or sagging of the web a remedy is occasionally provided by raising the position of the stroke of the comb on the face of the doffer. Vice versa for too tight a web.

It is the duty of the card erector to see that the relative heights of doffer and doffer comb box will allow of the exact position of stroke

of comb being readily obtainable. Frosty mornings, very cold rooms, slip of cord for driving doffer comb, may cause the web to break.

The web is the recorder or indicator of how the card is doing its work in regard to quality, and is frequently examined by those more or less responsible, a piece being taken from the web if exact knowledge is desired. A web usually shows up somewhat duller and more cloudy just before stripping.

Thick and thin places, flocks, general or local cloudiness, neps, bits of leaf or seed, defective selvedges, are the more common defects, liable to appear in the web or fleece of cotton delivered from the doffer. After cards have been stopped for some time, and the atmosphere has been damp, a sprinkling of French chalk on the lap, and a polishing of doffer comb with same, have sometimes helped a card to start better.

Nep is sometimes present in the cotton lap behind the card, especially if comber waste is used; but it may be due to the neglect of grinding, or reckless grinding, and sometimes by want of setting or unskilful setting.

Effect of Card Pulley Changing: Counts Calculation.

A scutcher lap is 16 oz. per yard, card sliver required ·16 hank. What draft will be necessary, allowing 5 per cent. for loss in waste?

The effect of a larger pulley or taker-in for driving doffer, would be to proportionately increase the speed of doffer, and therefore of calender rollers, coiler, and sliver can. Also because the doffer, by means of the side shaft, drives the feed rollers and lap rollers, these parts would be equally increased in speed. The cotton would be fed and delivered more quickly without affecting the counts excepting indirectly in the finest possible degree. The cylinder, taker-in, and flats would remain at the same speed as before, and as these are the principal cleaning organs the more rapid feeding and delivering of the cotton would reduce the quality of carding.

Method 1.—The first step in finding the draft from particulars given will be to find the counts of lap.

The short rule of this is as follows: Divide the weight of 1 yard reduced to grains into 8·33 repeated,

$$\therefore 8{\cdot}3333 \div 7000 = {\cdot}00119 \text{ counts of lap.}$$

Now divide the counts of sliver by the counts of lap,

$${\cdot}16 \div {\cdot}00119 = 134{\cdot}369 \text{ effective draft.}$$

The 5 per cent. loss in waste requires the mechanical draft to be 5 per cent. smaller than the effective one. Hence

$$\frac{134{\cdot}369 \times 95}{100} = 127{\cdot}65 \text{ final answer.}$$

Note.—With regard to the constant 8·33 as used above we might point out that it is obtained by dividing the 7,000 grains contained in 1 lb. by the 840 yards contained in one hank.

Method 2.—

$$\frac{8{\cdot}3333}{{\cdot}16} = 52{\cdot}08.$$

Then $$\frac{7000 \times 95}{52 \times 100} = 127{\cdot}65 \text{ as before.}$$

Production.

The small bevel on the side shaft for driving the feed roller affects production as well as counts, so that a larger bevel would give about the same length of a heavier and thicker sliver.

A larger barrow change wheel would keep the counts much the same, but would increase production by feeding and delivering the cotton more quickly. Allowing for all contingencies of stripping, grinding, alterations, and incidental stoppages about 9 per cent. may cover the average production loss on all cards, new laps being put in with the cards working.

Fly from beneath the card may be removed two or three times per week and the grids kept free from fly.

Under casings of taker-in and cylinder may be removed about once per annum and well blackleaded. Custom varies.

Cards with Insufficient Production.

It is possible to increase the production of a carding engine in at least four well-defined ways, any one of which is sufficiently practicable to be adopted when all the circumstances of the case point to its advisability.

These four ways may be summarised as below :—

1. Increasing the speed of the whole of the machine by the application of smaller cylinder pulleys or else a larger top drum.
2. By thickening the lap or increasing its weight per yard.
3. By the application of a larger side shaft change bevel.
4. By putting on a larger barrow change wheel.

Far and away the most generally adopted and the most convenient method is No. 4, which is frequently resorted to in many mills in cases of either temporary or permanent alterations in the productive capacity of carding engines. This barrow change wheel is admittedly the change production wheel, and provision is made in every carding engine for its easy alteration in size. Assuming a greater production is required and the barrow change at present used contains 34 teeth, the change to a 35 wheel would increase production as 34 : 35. Practically speaking, this alteration does not

affect the hank or counts of either the lap or the sliver; it is convenient and cheap to have a few of these wheels to spare, and the change is made very quickly. A larger wheel equally increases the speed of the lap rollers, feed rollers, doffer, calender rollers, and coiler. The same effect could be obtained by using a larger pulley on the end of taker-in, for driving the doffer. No. 1 method is not often adopted, because the speed of the cylinder having once been satisfactorily determined in any mill, it is not often deemed advisable to alter it. Still there are occasions when a mill goes on coarser work, or it is considered that a higher cylinder speed could be advantageously adopted, and in some such cases the main pulleys are altered in size. This method also has the merit of not affecting the counts of lap or of sliver. No. 3 method, i.e. altering the size of side shaft change bevel, is frequently adopted when it is desired to alter the counts of the delivered sliver. For example, if we were needing a

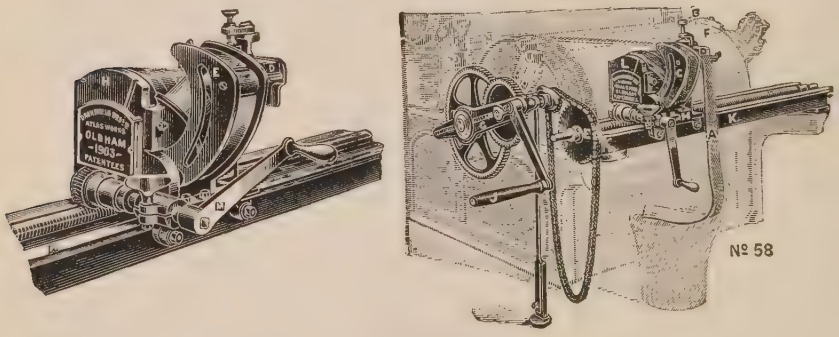


Fig. 32.

greater carding production to keep pace with the draw-frames, and we were satisfied our hank sliver from the cards was on the light or fine side, we could remedy both defects by applying a larger side shaft change bevel. This would have the defect of feeding a greater length of lap and delivering a greater weight of sliver, but not a greater length of sliver. A smaller change pinion could be put on the draw-frame to balance the counts and production. No. 2 method. —There are well-defined limits generally adopted for weights of lap per yard, and it is quite possible a case might occur in which the cards were unable to keep up with the draw-frames, and in which also, upon consideration, the weight per yard of lap was found to be decidedly upon the light side. If it were also known that the scutchers were already hard put to it to keep pace with the carding engines, then a good case would be made out for increasing the weight per yard of lap delivered from the scutcher and fed to the card. With-

out altering anything else at the card, the production of both scutchers and card would be increased, but the hank or counts of both lap and sliver would be lowered, and a correction of this would be necessary at the draw-frame at some later stage. Summarising these statements we thus have the conclusions :—

1. The most usual and convenient method of increasing the carding production is by using a larger barrow change pinion.

2. To suit special cases at least three other means may be adopted if required, these three ways being enumerated at the beginning of the present paragraph.

3. For quality it would be better to get more cards if the money and space can be found.

Card Mounting Machine (Figs. 32, 33).

The machine consists of a double-purchase jack, which is used for turning the cylinder (or doffer, as the case may be) ; a slide or bed, fitted into which is a long screw, which receives its motion from the jack through the chain gearing; and lastly, the actual tension apparatus, which is mounted to slide upon the bed; this apparatus receives its motion from the screw through the traverse wheel. When preparing to clothe, the bed is bolted on to the frame sides of the carding engine and the jack fastened upon the shaft of the particular organ intended to cover, cylinder or doffer; bushes are supplied to make up the bore of the jack to fit the varying diameter of shafts.

It is usual to clothe the cylinder first (of revolving flat and single roller cards); to accomplish this the doffer is removed. When clothing double roller and clearer cards, the back cylinder is clothed from the back of the card; the slow tumner, front cylinder, and doffer from the front. To clothe the tumner it will be necessary to mount a shaft or bar over the front cylinder in order to bridge the latter.

The widths of filleting in general use are 2 inches for cylinders, $1\frac{1}{2}$ inches for doffers. In using the mounting machine, the tension head will thus require to traverse correspondingly to the width being employed. For instance, if a 2-inch filleting is being mounted, the head will have to advance 2 inches for every revolution of the cylinder. For this purpose, change wheels are supplied with the jack ; these change wheels, which at one time were loose, and had the knack of being lost when wanted, are now fixed on the jack, and the latter has been so altered that the chain wheels employed in the screw drive give the necessary traverse. These chain change wheels are side by side, and when changing the width of filleting it is only necessary to pass the chain on to the correct wheel without any detachment being necessary. The jack possesses also a patent die fastener, which increases its hold upon the shaft automatically

as the tension upon the fillet is increased. This single die has replaced the old system of fastening with four, sometimes six, set screws.

The tension is secured in the *tension apparatus*, thus: The filleting is passed through the trough D, then wound over a three-coned pulley passing from one cone to the next over curved plates. Each cone is larger than the preceding one, and the largest is covered with leather. From the latter the fillet passes over the

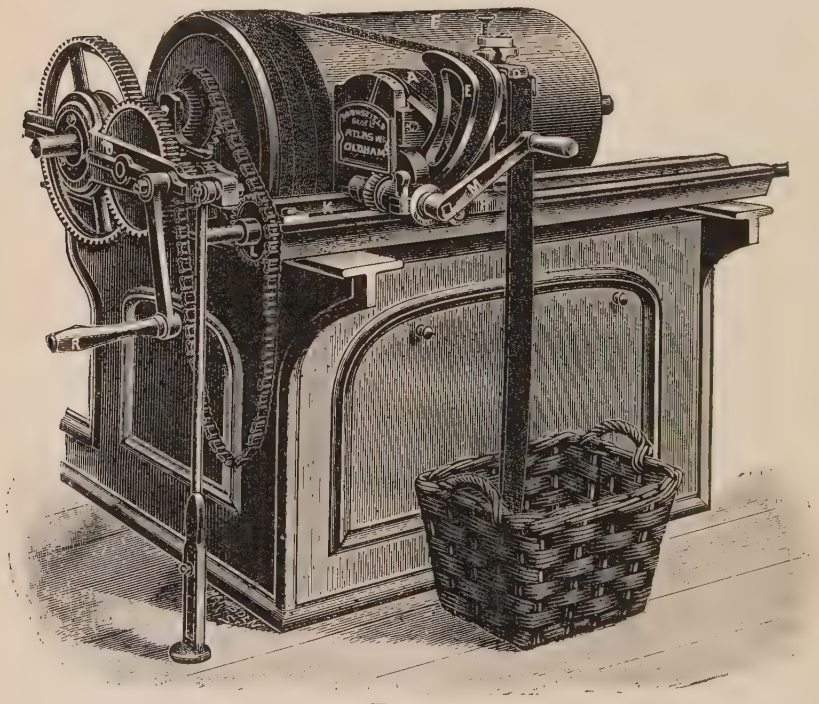


FIG. 33.

lever E on to the cylinder being clothed, in correct position for lapping; this lever actuates the finger, which indicates the exact tension put upon the filleting. The tension is gained in three ways. Firstly, the coned pulley gives 50 lb. tension on the back of the fillet foundation and not upon the teeth. Secondly, a variable brake on the shaft of the coned pulley causes the fillet to be drawn over the latter at a quicker speed than the coned pulley itself is permitted to revolve; this again creates "back" tension, the amount of which may be placed at 100 lb. Thus we have about 150 lb. of tension

gained without having to resort to pressure upon the card teeth. Thirdly, the remainder of tension required may now be obtained by screwing down the weight plate in the feed box D. The tension indicator H is divided and figured, the finger indicating very clearly the exact amount of tension applied upon the filleting.

Before commencing to wrap the filleting, all the wood plugs should be carefully examined to see that none are loose, and the edges of the cylinder chalked off to indicate the rows of plugs, as a guide for the nailing process after the cylinder is clothed. The filleting should be opened out loosely but regularly in a skip, and should stand thus for some three or four hours in the card-room previous to clothing, in order that it may attain the corresponding temperature.

The best means of wrapping a cylinder or doffer, and that in general vogue at the present time, is the so-called "inside tail-end" system, which permits of full and unbroken selvedges with an even circle or row of teeth at the extreme edges of the cylinder and doffer. The immediate result of such a method is an improved full-edged sliver.

Bare Cylinder Grinding at the Mill.

By placing two cylinders against each other it has sometimes been found that even new cylinders have not always been perfectly true.

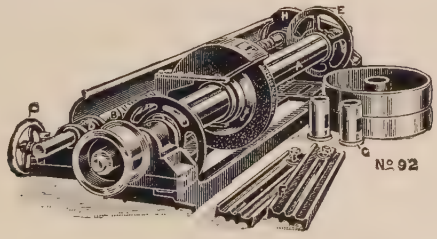


Fig. 34.

In the case of re-clothing some firms will examine the cylinders for truth.

An ordinary traversing emery wheel or Horsfall may be used for this. This may be slowly traversed across the cylinder, and careful gauge testings taken between the Horsfall and the bare cylinders.

Small rough places may have been caused on the bare iron by the crowns of the wire teeth.

In the case of new cards for foreign mills, the repeated transfer from one carrier to another has often led to want of truth, and especially when the cylinder and doffer shafts have to be re-inserted.

If either new or old cylinders and doffers are clothed while out of true cylindricality on the bare iron, then more grinding will be needed on the wire itself, with reduced life of wire, and sometimes about three days' hard grinding has been necessary for new wire before parallel setting could be obtained ; and most of this with the long roller.

Bare cylinder grinders are now in frequent use at cotton spinning firms. Such a machine is built on the traversing Horsfall principle, but with added strength and special parts. The emery wheel may be of consolidated corundum, mounted upon a strong steel tube and connected thereto by a strong key to maintain great rigidity. The traversing screw is arranged outside the tube and controls the lateral traverse by guide rods.

When using, the framing is stretched across the card near the cylinder or doffer as needed, and means are provided for quickly fixing the grinder parallel to its work before bolting in position. Special setting up arrangements are provided for obtaining and maintaining the depth of cut.

Dronsfield's Bare Cylinder Grinder.

This is specially constructed for the work, and is very substantial in all its parts. Many practical carders have known and recognised for years the importance of the point under consideration, and, previous to the invention of the special grinder, having no better appliance, made use of the ordinary emery-wheel grinder used for card grinding. Many of these were spoiled in this way, as they were never intended for heavy grinding of the type demanded in trueing up bare-cylinder surfaces. The bare-cylinder grinder is built on the traversing-wheel principle. The wheel is of consolidated corundum, and is mounted upon a strong tube, upon which it is traversed from end to end by means of a fork attachment with a double-way screw ; this screw is placed side by side with the tube (instead of inside as in the ordinary emery-wheel card grinder), thus keeping the tube intact save for the key-way ; this obviation of an open slot renders the tube very stiff and proof against any liability to deflect under the grinding pressure. Upon the tube ends are mounted two eccentric testing rings, which are used when setting the grinder in position on the frame sides of the carding machine ; the rings at each end are turned round until they touch the cylinder (or doffer), whilst the emery wheel touches at the centre. The bed carrying the grinder and traversing mechanism is then bolted down in position, the setting motion wheels serving to put the grinder into closer contact as the irregularity is ground away. The pulleys shown are fixed to the cylinder shaft ; the large pulley is employed to drive the grinder at a quick speed,

the smaller one fastened to it drives the screw and gives the traversing motion.

Application of Fillet.

It is necessary to mount the filleting in position on the various carding organs, viz. cylinders, doffers, rollers, clearers, and the accessory card-covered appliances, the stripping and burnishing rollers. In regard to the clothing of revolving flats, it is the custom to send these to the card maker or the machinist, except in isolated cases where the expense of transport is prohibitive and would entail much loss of time and production. In these latter cases the mill is provided with the necessary appliances, but great care has to be exercised in their manipulation.

Patent Spring Fork for Travelling Grinder.

Detailed improvements in grinding rollers have taken the form of oil pads to prevent the oil dropping on to the card; the socket end, to allow of a hardened shaft to run in the neck, and do away with wear in the screw shaft and tube end; increase of tube diameter from $2\frac{1}{4}$ inches to 3 inches.

The patent spring fork, Fig. 35, is designed to force the fork to run in the bottom of the screw thread, by this means preventing the fork from cutting away the screw edges, ensuring positive traverse, and reducing the wear and tear of fork and screw.

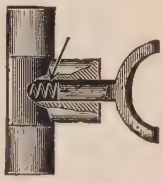


Fig. 35.

The emery-wheel grinder runs along a true tube, gets well at the sides of the wire teeth, maintains more accurate adjustment than the full-length roller, but the latter is quicker in grinding effect.

Emery Filleting.

There are two main kinds of emery filleting, grooved and plain. Messrs. Dronsfield say of their grooved fillet:—

"*The Patent Grooved Emery Fillet*, used the world over in all climates, is sharper, more regular in its action, and grinds a better point than plain covering in a little over half the time. The reason is explained as follows. The emery grains are of the angular type in both cases. Now, if these grains were simply dropped on the cemented surface of the fillet, it would simply be plain covered, but in the trueing-up process the sharp points of the grains would be forced down and the surface would become a series of mingled sharp points and flat sides of grains without any certainty of regularity. It may be computed that 50 per cent. of the best cutting points are buried.

"In grooving, the sharp angular points of the grains are forced up into grooves of such a pitch, that as nearly as possible one grain occupies a line; the result is a saw-toothed covering. For all practical purposes two pitches of groove are sufficient, a fine pitch for No. 40's and No. 7's with 16 grooves per inch, a coarse pitch for No. 6's and No. 5's with 8 grooves per inch.

"In this way, then, the full obtainable cutting power of every grain is brought into action, with the further advantage of having each line of grain acting upon a given quantity of card teeth. The filleting is so trued up that in testing the filleting mounted upon a revolving cylinder, a tool sliding upon a true slide will touch the top of every groove or ridge. This test is applied to filleting previous to packing for shipment.

"Emery filleting is made of any size of grain demanded, but the standard grains are No. 40's and No. 7's for hardened and tempered steel; No. 6's and No. 5's for mild steel. The former are the finer, and the latter the coarser grades."

CHAPTER III.

DRAWING FRAMES.

The Erection of a Draw-Frame. Introduction.

The erection of the draw-frame is a sufficiently important operation to merit every care in doing the work. If rollers are to revolve freely and easily, stop motions act promptly and always, the slivers to coil properly into all the cans, bad ends to be held back, and the tenters' work to be kept within reasonable limits—while production is maintained at a good standard, then the erection and gaiting-up of the draw-frame must be performed with skill and care. As in the case of other machines, about the first thing to do is to mark out the proper centres so as to ensure that the frame shall be exactly at right angles to the line shaft or parallel thereto, just as may be required. One method is to suspend a plumb from the line shaft at two different points a short distance apart, and either mark a chalk line on the floor or measure from the line to the frame direct. If required it is an easy matter to make a second floor line at right angles with the first one. A little consideration may be given to the question of whether the driving is direct from top shaft to the long bottom shaft, or whether gallows pulley driving is intended to be used.

It will be the duty of the fitter or of the management to see that all the parts are well cleaned and are made free from grease, remembering that the cotton is in a very loose state at the draw-frame, and the slivers have to pass in contact with several mechanical parts which cannot be too clean or too smooth for the free passage of the cotton. The parts are almost invariably rubbed with grease at the machine shop to prevent rusting and tarnishing during transit, and it is therefore a preliminary step in the erection of all cotton spinning machinery to see that all parts are adequately cleaned.

Draw-Frame Erection.

Floor lines may be obtained in manner elsewhere described. All grease to be cleaned from the machinery parts. Using the ordinary numbering of 1.1, 1.2, etc., and No. 1 or A for all parts of first frame of a series, with No. 2 or B for the second frame, secure

the frame ends to the roller beams. Keeping all letters and numbers in correct order and position will make draw-frame erection for the most part a simple procedure. The knocking-off shafts and back brackets may be attached to the beam or frame, followed by most of the parts required for the back or feed side of draw-frame. To the front of the beam may be secured the calender brackets and the calenders put in place. Then the press plate, press wheels, and arm wheels. Screw and bolt up firmly, apply any steady pins, and then fix the spring pieces in position and properly secure to beam. The draw-frame may now be squared and levelled up by using a good spirit level crossways and lengthways of the machine. Wood packings to be used as needed beneath the frame end feet, but spring pieces, perhaps, by means of the screws which rest on loose cast-iron washers. Under the front edge of the beam may now be placed the shaft from which are driven the press plates and coilers.

Weight-relieving motions, weight wires and hooks may now be applied, and the relieving motions adjusted to give accurate effects without dislocating weights, wires, or hooks. The main or bottom driving shaft can now be filled in, leaving 5 inch projecting end for the one pulley drive or about 1 foot if fast and loose pulleys are used. The quarter crossed belt drive requires accurate setting to keep the belt on without fork and to prevent the belt from catching the frame end. For the standard 36 × 9 inches sliver can, there may be 37½ inches from can dish to press wheel plate, and the centre of the can dish may be set towards the front and out of line with the press wheel. All details of final screwing up, thorough cleaning, any fixing of clearers, change wheels, stop motions, roller settings will be taken as convenient and before the frame is ready for starting.

In the case of new frames, the erector should see that the covering of rollers and clearers is receiving attention from the first, if the machinist has not been required to attend to the covering. Keep in a dry warm place until wanted. French chalk is convenient and suitable stuff for cleaning steel rollers and all polished metal parts over which the loose cotton sliver passes. At first 60 minutes' running without cotton is recommended.

Front stop motion trumpets may be finally balanced and tested when working so as to stop the frame when anything less than two-thirds of the normal weight of cotton is passing forward.

Back spoons should be suited to the counts or hank of sliver stated by the spinning firm, and should drop at hook end or knock-off when a sliver fails or becomes less than about two-thirds the normal weight. Tips of spoons when down may rest on centre of bar.

Any kind of knock-off motion should be set to stop the frame

when the first cans are sufficiently full, and in some cases it may be advisable to show the tenter how to replace in empty can position.

An important detail is to examine the sliver for slackness or stretching between the delivery draft roller and the calenders, and to alter a tooth on the calender wheel if necessary to get this correct. Similarly examine or correct the sliver between the back preventer or lifting rollers and the back-draft rollers, with the cotton on the spoon lever. Heavy slivers may cause a slackness which eases sliver from spoon and wrongly stops the frame. A suitable wheel tooth may be altered, or in extreme cases a roller diameter slightly diminished.

Setting of Sliver Can.

Each coil barely short of the inside edge of the can to a point just beyond the centre of the can. In particular should regard be bestowed upon such points as relate to the coiling of the sliver if there have been any more or less substantial changes in the thickness and weight of the slivers. Light slivers require less space than heavy ones, and we may, therefore, put rather more coils in one revolution of the can by reducing the speed of can. If coils reach short of the can side there may be spaces left for some of the slivers to fall into and then afterwards bind and break in the withdrawal, and in such cases a slower coiling speed would give more sliver for each coil, and therefore a somewhat larger coil, and more throw against the can side. That is assuming the rate of delivery of the sliver be maintained as previously. If coils are too large they throw against the can side, and may overlap and ridge somewhat, while if the coils are too small there is not as much weight of sliver in each can as there might be.

Gaiting-up of New Frame.

There are various items appertaining to the erection of new draw-frames, which may be conveniently placed under the general heading of starting or gaiting-up. The fixing up of the can box may perhaps not be considered as belonging to this head, but we have included it therewith for convenience.

The Can Boxes.

There are two chief points requiring attention with regard to the fixing up of the can boxes, the first one being the height of the box in relation to the press plate, and the second point being the relative position of the centre of the can box in regard to the centre of the coiler at the top. The most used standard diameter of can in the English cotton spinning trade is 9 inches, and in this case the centre of the bottom dish for the can may be set $1\frac{1}{4}$ inches more towards the front than the centre of the coiler in order to properly

dispose the coils in the can. As regards height there may be $1\frac{1}{2}$ inches or more clearance between top of can and press plate at the top.

Before starting a new frame a careful fitter will see that all bolts and nuts are properly rung up, and all the bearings of shafts and rollers are efficiently lubricated. Also, another cleaning of the parts may be necessary after the erection, and before starting. On a draw-frame there are usually slight tension drafts on the cotton between the preventer rollers and the draft rollers at the back or feed of the machine, and also between the front delivery draft roller and the calender rollers at the delivery side of the machine. These slight drafts are somewhat affected by local circumstances, such as thickness of sliver, and should be carefully checked by the fitter and the management in order to secure the best results.

The Rollers.

When a new machine is being started it frequently happens that one or more of the bearings will bind more or less, and will rapidly become very hot, and unless very quickly detected serious damage to the bearing may result. This is one of the features demanding special care in starting up a new draw-frame just as in the case of other machines. Apart from the various parts of the front and back stop motions, there are comparatively few parts on a draw-frame which need much skill and experience in adjustment, this machine being much easier in such respects than are, for example, the card, comber, fly-frame, and self-acting mule.

Not only do the tension drafts before alluded to need testing and checking, but also the three middle drafts between the four pairs of drawing rollers should be carefully ascertained and checked. The writer is no believer in the idea of making the middle one of the three drafts to be the largest, rather preferring this to be the front one, or delivery of the three; and assuming six ends up it is sufficiently good in actual practice, and a very easy thing to bear in mind, if we have the first or back draft $1\frac{1}{4}$, the second or middle one $1\frac{3}{4}$, and the third or last one sufficient to give the required total of six, the draft change pinion usually permitting ready adjustment of the third or largest draft in order to get exact counts of sliver required.

The Coilers.

In a thorough example of overhauling a draw-frame the coilers and front can arrangements should be included in the list for special attention. A chief point in this connection is the disposition of each front can. There is a more or less frequent tendency for these cans to get out of the perpendicular due sometimes to

defects in the cans themselves, but also often due to the foot plates and can holders becoming more or less disarranged.

Take the case of a standard can of 3 feet in length. It is very easy to realise that a drop of $\frac{1}{16}$ inch on one side of the foot plate or can holder will throw the top of the can quite a distance out of the true position in relation to the coiler working over the can. Every foot plate should be placed in a proper horizontal position, whether the spirit level or other means be used to check the same. Without doubt a slight error in the level of the foot plate will cause the sliver to be disposed in that can in an improper manner, since one coil would press too much against the can side while another would fail to touch the side, the evil being most apparent towards the top of the can. Apart from all this a check may be placed upon the speed of the coiler in relation to the rate of sliver delivery and the thickness of the sliver, as this vitally affects the size of the coils, while the relative speeds of parts affect the number of coils per revolution of the can.

Manipulation of Drawing Frame.

Loose bush ends or loose bosses may be taken off, thoroughly cleaned, and re-oiled once a week.

High-speed bearings, such as front-roller bearings and calender rollers, are best oiled twice daily, but lower speeds, such as can boxes and press wheels, may take only once per day.

At periods varying from ten to twenty weeks fluted rollers may be lifted out, laid on suitable bearings, and thoroughly cleaned and scoured. At these periodical scourings all parts of the frame should be very efficiently cleaned. Gearings and many of the bearing points should receive fresh tallow or special grease.

It is best to support the steel rollers under every bearing on a suitable framing when scouring. Scouring times vary greatly in different mills. Top and bottom clearers may be picked every two hours. In very many cases top rollers are varnished every few weeks, more for Egyptian than for American cotton.

Draw-frames, Oiling and Cleaning.

Quickest and chief bearings may be oiled twice daily and other bearings once.

On draw-frames with electric stop motion, the necks of the top cast-iron calender rollers, which make contact for broken slivers, should never be greased.

To get the best results from the mechanical stop motion every spoon should be properly balanced and free from fly and dirt.

Fluted rollers may be taken out three times per annum for a forty-eight hour week—some firms still do this four times yearly.

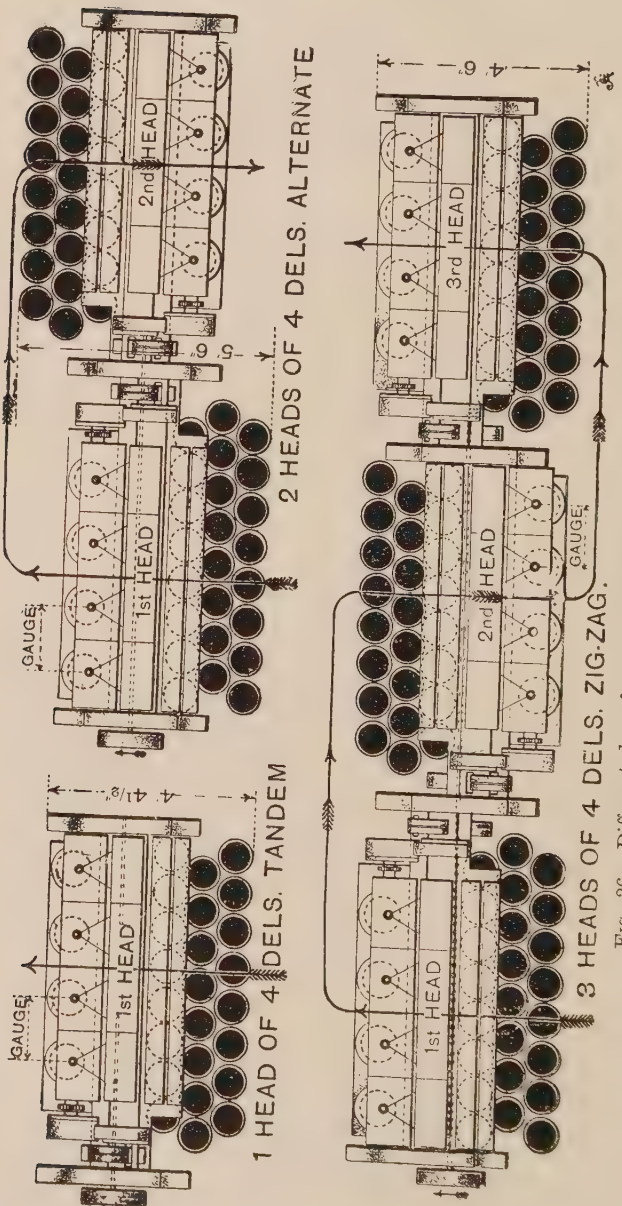


FIG. 36.—Different draw-frame arrangements. (Brooks & Doxey.)

The scouring of the steel-roller flutes should be effective and all bearings well cleaned and greased.

Not only should the wheel studs be kept well oiled or greased, but all the better if grease is kept on the wheel teeth.

Varnishing is probably more frequently done on draw-frame rollers than any other. Some good firms on American cotton will varnish all four lines of top rollers once weekly.

Sometimes for Egyptian cotton the front or delivery line is varnished twice weekly and the other three lines once.

Perspiring hands and symptoms of oil or grease are fatal to the free passage of the sliver down the front trumpets or funnels. These funnels and any of the polished metal parts over which the sliver passes are all the better for treatment with French chalk, which is finer and dryer than ordinary whitening.

Many patent-top clearers are used for draw-frames, a great favourite being Ermen's as now made by almost any good firm. If the ordinary stationary flats are used they may be picked every two hours, and the stationary under clearers twice daily.

Oscillating under clearers are used by some firms.

Roller Varnish.

The question of roller varnish seems to associate itself with the draw-frame more than with any other individual machine in a cotton-spinning mill although it is important on the comber. There are indeed many mills using American cotton and making only carded yarns which scarcely ever recognise the use of varnish officially excepting for just the draw-frame. Every overlooker or carder connected with the trade knows that the varnish question has always been a debatable one from two or three points of view, such as follow: Is it wise to varnish at all? Which machines must have the rollers varnished? How often shall we varnish? Shall we varnish only the front top line or the first two lines, or all the lines of rollers? What colour of varnish will be best? Shall the varnish be applied with the rollers in the machine, or shall the rollers be taken out? Is it worth while using a machine to help in varnishing? Shall the varnish be in permanent liquid form, or shall it be in a semi-solid form which will liquefy upon subjection to a certain amount of heat? How long should it take a varnish to dry? What are the special advantages to be expected from varnishing?

The use of varnish is somewhat akin to the use of artificial humidifying, inasmuch as both are somewhat dependent upon weather conditions for a full display of their advantages. For example, a prevalence of dry frosty weather is well calculated to enhance the possible advantages of either one or other of these two accessories to the practice of cotton spinning. It has happened in

numberless cases of self-acting mules or ring frames, that a proper start could not be made on a very dry frosty morning until after the front top line of draft rollers has been varnished. These cases show up most strongly when the spinning is normally kept pretty near the going limit so that a little extra roller lapping or thread breakage has acted like the proverbial last straw to the camel's back. There can be no doubt that rollers somewhat recently varnished with a good varnish carefully applied are much less subject to roller lapping than are rollers with the varnish worn off and the leather surfaces somewhat roughened.

The present writer has often been asked for recipes in regard to roller varnish, and has had some rather curious experiences in connection therewith. For example, in the course of a lecture given before a class of managers and overlookers two different recipes were written on the blackboard for the members to copy, and for the purposes of discussion. After the lecture a manager member of the class came up and said he understood one of the two varnishes was in the nature of a semi-secret, and sold under pledge of secrecy to a certain number of spinners, and his own firm had paid £5 for the same some months ago. A carder who overheard him said : " And we paid 7s. 6d. for it a few weeks ago." The present writer was easily able to prove that he had been giving that same recipe off and on to his honours students for a period of ten years previous to that particular date. There is a great deal to be said for the purchase of varnish manufactured by people who specialise in this line, and who make a special study of such points as the particular kind and density of varnish which has proved to be best suited for the rollers of certain people ; the question of whether the counts of yarn are coarse, medium, and fine, and variations in the materials used in the varnish. To illustrate this latter point a few months ago a somewhat well-known specialist in roller varnish informed the writer that he had almost lost several of his best customers because in an apparently unaccountable manner the quality of his varnish had all at once gone off, both in effectiveness and in durability. There was no doubt the component parts had been blended in the correct and well-proved proportions, the breaking up, boiling, and putting up had been along the known satisfactory lines, and yet the varnish was undoubtedly much below the average. Finally, it was demonstrated without doubt that all the fault lay in the purchase of a rather large weight of glue which was distinctly below the standard in the qualities of thorough blending and of adhesiveness. This incident is given because it conclusively shows that something more is needed than a good recipe and care in mixing and making the varnish. It is highly essential that guaranteed materials be purchased from reliable dealers.

One of our eminent machine makers has long published the following recipe for roller varnish: Take 1 lb. of chrome yellow and mix with $\frac{1}{4}$ lb. of lamp black and $\frac{1}{4}$ lb. of rouge, rolled well with a roller to take out all the small lumps; then get 10 oz. of joiner's glue, and boil it in 2 quarts of water. Add to the above, and let it simmer for half an hour, continually stirring it. If it should be thicker than ordinary paint dilute it with warm water and varnish. Before using this varnish will require slightly warming.

Another eminent machine-making firm gives a recipe somewhat as follows: $\frac{1}{2}$ lb. of common glue dissolved in a quart of cold water for a day and night; $\frac{1}{4}$ lb. of gum arabic dissolved for a similar time in half a pint of cold water. A mixture of powders such as chromate of lead, sub-chromate of lead, green paint powder, and black lead ore all ground well together in water until resembling putty. Glue and gum mixed together and additional water added and simmered along with the pigment powder for about six hours, adding about two tablespoons of wood naphtha. This varnish cools off into the form of a jelly, portions being cut off as required, warmed up and applied with a suitable fine brush.

Many firms purchase their varnish from reputable firms, but there are several good recipes from which some spinning firms make their own varnish.

One such recipe is as follows: 1 lb. venetian red, $1\frac{1}{2}$ lb. fish glue, 9 lb. of acetic acid. Boil well together, stirring occasionally, for possibly four hours. Apply with a soft brush.

Grinding, Trueing-Up, and Varnishing Machines.

We can scarcely dismiss the subject of roller varnish without referring to the increased practice of using machines for trueing up leather-covered rollers, so that after being re-varnished they are then capable of good service again in the mill.

There has been designed a machine for grinding and trueing-up leather-detaching rollers for combers, and it was so successful that shortly it was adopted for draw-frame top rollers also, and now it can be used for almost any kinds of top-covered rollers as used in a spinning mill. Anyone who has a slight knowledge of the construction and action of a cotton comber knows how important it is for the detaching rollers to be perfectly cylindrical as they can be got, and hence the first invention of this machine. In this machine the leather-covered roller to be ground and trued up is fixed in two brackets on the table, these being adjustable to admit varying lengths of rollers, and one of the brackets having cross adjustment to permit the rollers to be set perfectly parallel. A high speed is imparted to the roller under treatment, say up to 1,400 r.p.m. or so for the fast and loose pulleys of $3\frac{1}{2}$ inches

diameter. Attached to the fast pulley there is one for giving motion to the pulley on the lower shaft, which again gives motion to the small pulleys for rotating the top rollers. On the reversing shaft is a worm working into a worm wheel, which gives a longitudinal reciprocating movement to the table by means of a rack and pinion. The leather covering of the top roller is brought into contact with the grinding disc by a vertical screw, and the feed is applied to the grinding surface by means of a ratchet wheel (connected with the screw), and a catch actuated at each traverse of the table by a slide bar, which is adjustable to any length of roller. The grinding material for covering the metal disc may be either emery cloth or glass cloth, or even paper coated with these substances. Sandpaper is also a good grinder, two strips being fastened tightly on the periphery by means of the small plates and screws. There are two small brass pulleys for putting on the ends of the top rollers, and these must be fixed inside the two brackets. Varnishing follows grinding necessarily. There are machines now used which are equally convenient for trueing up and varnishing. The reader is referred to the Chapter on roller covering for other discussion on this subject.

Re-setting.

Carding engines, combers, fly-frames, and self-actor mules stand out very prominently in this connection, the first two of these needing general adjustment and re-setting probably more frequently than any other machines in the mill. Special gauges of various kinds are required for combers and mules in cases of re-setting, and plain thin gauges for the carding engine. In the case of self-acting mules it has oftened happened that an expert fitter has had to spend a matter of two or three weeks' time in order to thoroughly re-set, repair, and bring the machines a little more up to date.

As it happens, the drawing-frame is such a simple machine, the parts that are liable to wear and get out of order are so few, and there are so few parts of an intricate, or intermittent, or shaky nature, that there is comparatively little occasion or need for subjecting it to anything in the nature of a thorough overhauling and re-setting in the sense that a comber or mule may need such attention. There is scarcely any other machine in a spinning mill which requires so low an expenditure in this respect as does the drawframe, while it is nevertheless a very productive machine, and is economical in regard to wages expenditure. At the same time the drawing rollers, the clearers, the front calenders, and the parts concerned in coiling the cotton in the front cans, have a good deal of work to do, and it is usually in connection with these parts and the automatic stop motions that special re-setting or repairing may be deemed necessary at intervals.

The Draft Rollers.

The draft rollers of a draw-frame have usually more work to do than those of any other machine, since they revolve at comparatively high speeds and operate upon thick slivers. In ordinary cases of re-setting chief interest might be centred upon the draft rollers; the leather ones being re-covered, the bearings being put into good condition, and note taken if the middles and ends are at all worn. If brass bits have been used for the bottom rollers in the stands these should be examined and renewed if wear is observed. The necks of the rollers and the bearings on the stands are often liable to wear, thus causing the rollers to work lower than should be, and also causing the rollers to bear on one side instead of assuming a fresh position in exactly the same plane as before wearing. This often causes the top rollers to press hard against their bearings, and giving abrasion which causes the rollers to become dry sooner than should be. Such evils as these are probably not so great now as was formerly the case owing to the extensive adoption of front lines of bottom rollers case-hardened all over and the other lines case-hardened in the necks or bearings, combined with the very general adoption of the loose ends for top rollers. In any case of repairing, both top and bottom rollers should be put into the best working condition in every respect; consideration should be given to such points as the application of better clearers, and the rollers should be re-adjusted in quite parallel lines at correct distances from each other centre to centre. The question of setting and maintaining the top rollers exactly parallel with the bottom ones is of even more importance with metallic rollers than with leather covered ones since any want of such order in the case of metallics may lead to flutes of top and bottom rollers riding upon each other, but parallelism is a good feature in any rollers in any machine. In many cases of a thorough overhauling the extreme step of changing from ordinary to metallic rollers has been taken, while curiously enough there are some other cases in which the opposite practice has been followed, the question of the relative merits and demerits of metallics being one in which there has been for years much difference of opinion, and since it has been discussed almost threadbare in these columns, we propose to say very little about them in the present series of articles. It should not be a difficult matter to line up the stands so that both top and bottom rollers shall revolve quite easily. The frames are too short to give so much difficulty in this connection, and there is also the distinguishing feature that both top and bottom rollers of one pair are often sustained in the same vertical bearings, and cannot be individually adjusted.

The Calenders.

The front or delivery calender rollers of a draw-frame are now often made of 3 inches diameter, and at this diameter sometimes make as many as about 200 r.p.m., so their weight and speed combined often lead to wear in the bearings. No overhauling would be complete, therefore, without attention being given to these bearings of the calenders, and steps should be taken to put these in good working order, each bearing doing its share of work, and an endeavour made to get a good equal bite of the cotton at all points of delivery of sliver in the length of the frame. Tests may readily be made as to the grip or biting capacity of the rollers upon thin portions of sliver or upon paper of suitable thickness. On some frames one calender is put in a slightly lower plane than its companion, although this may not be a universal practice, but in any case a good grip of the cotton is required for regular conducting of the slivers from draft rollers to coiler and can. Attention should also be given to the question of draft between the front calenders and the delivery draft roller, this being checked to see if in accordance with the ideas of carder or manager. Before now cast-iron bushes have been put upon the bearings of the calenders in cases of repairing when sufficient wear has been evidenced. There should not be much draft between the front draft roller and the calenders, but at the same time there should be sufficient to prevent the sliver passing forward in a sluggish, irregular, dragging manner.

Many carders and managers are of opinion that a slight draft is beneficial at this point, as it not only remedies the dragging action just referred to, but also to a very slight extent makes the sliver finer for the slubber, and may help to limit the number of bad ends. In a case of an actual frame checked by the present writer many years ago, the following particulars were ascertained as an example of this draft for American cotton: Diameter of front roller $1\frac{1}{4}$ inches, and diameter of calenders 3 inches. A wheel of twenty-one teeth on the front draft roller gave motion through a carrier to a 48 wheel on the calender. From these particulars the tension draft is determined as below:—

$$\frac{21 \times 3 \times 3{\cdot}1416}{48 \times 1{\cdot}25 \times 3{\cdot}1416} = 1{\cdot}05 \text{ draft.}$$

Dr. Ure in 1836 wrote as follows:—

"Sir Richard Arkwright, the undoubted inventor and first constructor of the drawing-frame, was so impressed with its importance in automatic spinning, that when any bad work was turned out, he immediately desired his people to mind their drawings.

"The draw-frame is intended to straighten the filaments, and it likewise serves to equalise the constitution of the cotton wool,

by uniting many slivers into one, so as to mutually correct each other's defects.

"The cards, no doubt, tend to straighten many filaments, but they also double not a few by catching them in the middle and the drawing undoes all these foldings when it is well conducted.

"The machine consists of upper and under rollers, the former being smooth, and covered with an elastic leather coat, the latter being fluted longitudinally, in order to seize and pull along the slenderest filaments. Of such twin rollers there are usually three pairs in one line of traction, and one parallel plane, whereof the under ones are driven by wheel work, with successive degrees of velocity, and carry round, by the mere friction of the sharp-edged flutings, the upper ones which are pressed upon them by considerable weight.

"A convenient and common method of increasing the speed of the front roller without being obliged to use wheels differing too much in diameter, is to make that roller somewhat thicker than the others; so that it may be $1\frac{1}{4}$ or $1\frac{3}{8}$-inch diameter, while the others may be $\frac{7}{8}$ or 1-inch diameter."

Were the drawing of a single sliver attempted to be continued until the suitable parallelism of its filaments were effected, it would ere long become an impossible operation, on account of the excessive attenuation of the riband. This inconvenience is obviated by the very simple method of associating at each repeated drawing several of the formerly drawn slivers, this being the process called doubling.

Doubling and Drawing.

"In the preparation department for spinning the mean counts 36's to 40's three drawing heads are used, and the doubling upon these heads is as follows: $\frac{6}{1}$, $\frac{6}{1}$, $\frac{9}{1}$, constituting one multiple sliver after 324 doublings. In other good factories, four drawing heads go to one carding.

"In the finest spinning mills (before combing was used) the doublings are far more numerous, of which the following numbers form a good example:—

$$\frac{8}{1}, \frac{4}{1}, \frac{7}{1}, \frac{6}{1}, \frac{6}{1}, \frac{6}{1}.$$

"If these numerators, which indicate the number of slivers united at each successive drawing, be multiplied together, they will give the product 48,384, to which may be added another doubling at the bobbin and fly-frame, or the stretcher mule, constituting in all nearly 100,000 times that the fibres are repeatedly placed parallel to each other before a thread is attempted to be spun."

Bad Ends or Slubs.

Like varying counts of yarn, bad ends or slubs are always more or less with us, and vary from those due to over-running of the top creel bobbins at the mule when the quick-running carriages finish each outward run, to those due to the draw-frame.

Slubs or bad ends are chiefly caused by dirt and fly accumulating at certain positions adjacent to the passage of cotton at one or another machine, and then connecting to and passing along with the cotton strands.

Small portions of dirt readily attract loose fibre. The better the qualities of produced yarn, the more important it becomes to keep the yarn free from bad ends, and even combed yarns give plenty of trouble in this particular direction. Constant watchfulness, and systematic cleaning on the part of careful and competent operatives, is perhaps the greatest safeguard against bad ends in the yarn.

At the opener or scutcher "catches" of fibre may form on the sides of the interior and then pass forward into the lap, and it does not follow that all of these are properly opened out at the subsequent carding process. Bad ends or slubs formed at the carding engine may be too short and small for drafting out at the rollers of the later machines.

A good licker-in action at the card is necessary if unopened tufts of cotton shall not pass forward. Under casings set too wide, card wires broken-out, bent, very dull, and dirty may permit unopened portions of cotton to pass forward and afterwards cause bad ends.

Possible causes of bad ends are under casings set too wide, doffers too far from cylinder or not uniform across the card width, imperfect action of doffer comb, neglect of stripping and grinding at the card, flats running too slowly, bad selvedges to the fleece or web of fibres from the doffer.

At the draw-frames constant attention is needed to get the best results from top and bottom roller clearers, and unless this is done we are sure to have slubs. Any defects in the rollers, or any neglect of cleaning at any part of frame touched by the cotton, may lead to slubs or bad ends.

Picking of flyers at proper times and in a skilful careful manner, and every attention to the rollers, clearers, and flyers generally, are needed to prevent bad ends forming at the bobbin and fly-frames. Traverse guides at every machine want attention to prevent bad ends.

Wafting of creels, blowing of traverse tins, over-head sweeping, accumulations of fluff on middle rollers, back tins and guide rods, one thread breaking and partly going upon an adjacent one, loose

ends broken in backing-off and winding-on, over full top and bottom clearers, are causes of bad ends on the mules.

Careless and unskilful piecing of broken threads is more likely to cause bad ends on the ring-frame than on the mule.

Draw-Frame Stop-Motions.

For very many years there has been difference of opinion in regard to mechanical versus electric stop-motion for draw-frames.

1. The kink plates for guiding the sliver from back cans to rollers do not always perfectly open out knots of sliver, and sometimes such a knot will hold a top roller up and prevent operation of electric stop-motion when an end breaks. This cannot happen with the mechanical motion. Sometimes such a knotted portion passes through the rollers and chokes up the trumpet at the front and yet the front calender stop-motion does not act.

Very thin slivers will often stop the frame with the mechanical motion, but fail to do so with the electrical.

Another possible defect is a soft piecing made at the card may be drawn out by the slight draft between the electric rollers and back draft rollers, and yet the electric rollers continue to pass the sliver forward and cause the latter to gather on the plate supporting the electric rollers.

Apparently the electric stop motion gives an unscrupulous tenter a better chance of passing defective work forward without stopping the flame.

Draw-Frame Calculations.

A drawing-frame of three heads, of six deliveries each, is required to produce 3,000 lb. weekly of ·20 hank sliver; the card sliver is ·244 hanks, and the drawing-frame front roller is $1\frac{3}{8}$-inch diameter. Find (*a*) draft in each head, (*b*) speed of front roller, assuming the frame runs 54 hours per week, and that an allowance of 22 per cent. is made for stoppages.

(*a*) Take the draft first. It is not stated how many ends up. Assuming six ends up at each head, making no allowance for waste, and allowing "drawn" counts to be the same as "carded" counts, we should have a total draft of $6 \times 6 \times 6 = 216$. But the drawn counts are stated to be coarser than the carded counts, and this implies a proportionately lower total draft,

$$\therefore \quad \frac{216 \times \cdot 20}{\cdot 244} = \text{total draft} = 177.$$

$\sqrt[3]{177} = 5{\cdot}61$ draft in each head.—First answer.

Assuming the draft in each head to be the same.

$$(b)\ \frac{\text{Revols.} \times 11 \times 22 \times 54 \times 60 \times 6 \times 78}{840 \times 8 \times 7 \times 12 \times 3 \times \cdot 20 \times 100} = 3{,}000 \text{ lb.}$$

$$\therefore\ \frac{840 \times 8 \times 7 \times 12 \times 3 \times \cdot 20 \times 100 \times 3{,}000}{11 \times 22 \times 54 \times 60 \times 78 \times 6}$$

= Revolutions = 276·88 per minute.—Second answer.

Trumpet Holes.

In dealing with the question of bad ends we may refer to a detail of practical importance which does not appear always to receive the attention it merits. We refer now to the sizes of the various apertures to which the cotton slivers pass through on their way from the back feed cans to the front delivery cans. Take, for example, the front coiler tubes or trumpets. If these are too large in the apertures they will permit over-thick slivers and bad ends to pass forward, and this detail is of such importance that cases have been known where the amount of bad ends in the rovings and yarn has been very greatly reduced by no other alteration than obtaining a set of new front tubes or trumpets at the draw-frame, with smaller apertures that will allow very few bad ends to pass, but will stop the frame instead. Formerly these trumpets were very usually made of brass, but more recently they have become extensively made of cast iron, and these latter are not only decidedly cheaper, but cannot be as readily knocked up or otherwise injured by the draw-frame tenter. Speaking in a general way, machinists more usually make the trumpet apertures small enough, but often they are unduly opened by the attendants, since this allows the work to pass forward more freely at the draw-frame. It is a somewhat humorous but none the less true saying by many operatives, that they are paid better for allowing all work to go forward than they are for stopping their machines to take out bad ends and other defective material. Aluminium has also received favour for trumpets.

The kink holes—whether vertical slit or merely round apertures for threading slivers through—should be as smooth as possible, and as near the correct size as can be reasonably obtained. If they are in any way rough the fibre will gather on them and make bad ends, while if they are too large they may allow kinks of sliver to pass, and if too small may cause undue breakages of sliver. At the first glance one would scarcely think that the apparently thick sliver would ever draw through the small aperture in the front trumpet, and it is astonishing what is regularly done in this direction. Each trumpet forms part of the front stop motion of the draw-frame, and it is now often the case that a thick sliver is expected to pull down and forward at the trumpet to a degree sufficient to intercept the rock bar and automatically unlatch the stop rod and stop the frame.

It is, of course, a regular part of the stop motion for a light sliver to permit the trumpet tube to lift, and in this manner to stop the machine, thus forming a double-acting stop motion, although this may or may not be associated with the principle of stopping the frame whichever way the bar happens to be moving.

Draw-frames and Egyptian v. Indian Cotton.

A good many firms have the draw-frames arranged for eight ends for Egyptian cotton, but no more than six would be specified for Indian cotton in any case. The weight per yard of sliver for the Indian would be greater and so a full can would not contain as great a length, and this would require on some measuring motions a different change wheel for full can motion. The chief point would be that rollers of smaller diameter would be specified for the Indian cotton, while the speeds of rollers would be much higher for the Indian cotton, and point would require attention in the pulley sizes. $1\frac{3}{8}$ inch, 1 inch, $1\frac{1}{8}$ inch, and $1\frac{1}{8}$ inch bottom iron rollers might be used for Indian. For Egyptian the diameters might be $1\frac{1}{2}$ inch, $1\frac{1}{4}$ inch, $1\frac{1}{2}$ inch, $1\frac{1}{2}$ inch respectively. Diameters of top rollers in each case rather less than the bottom ones. For the Egyptian cotton many firms would insist on some kind of mechanical top clearer, whereas it is possible for Indian cotton many people would be satisfied with the cheaper and simpler stationary flat. A wider gauge of can and pitch of roller, and power to give wider centres of rollers would be necessary for the Egyptian with eight ends up. The trumpets for the slivers would need smaller apertures for the Egyptian.

The draw-frame is not a machine which contains many parts other than those directly connected with the rollers, and it is therefore around the roller details that the differences would centre. Dead weighting or lever weighting are optional on the draw-frame, but nearly everyone for Egyptian cotton prefer the dead weighting, while there is greater variety of opinion on this point for Indian cotton. The single preventer or assistant sliver lifting motion is perhaps more necessary for the Egyptian on account of the finer sliver, but many would use it also for Indian because of the weakening of slivers due to shorter staple of cotton. In the same way it may be said that metallic rollers would be optional in either case, according to the opinions of those in charge.

Specification for New Draw-frames.

When ordering new draw-frames it is necessary for the mill officials to fill in specifications for the guidance of the machine maker, who usually is ready to supply official query forms requiring answers appending at the spinning mill. The machine makers are generally ready to give any desired advice as to the merits and

demerits of any special arrangements or devices. For example, an officially filled in form might read somewhat as given below. Number of frames required, ten. Three heads or passages per frame, with six deliveries per head. The deliveries to be arranged alternately so that the cans of sliver filled at one head can be moved easily to the feed of the next head, and one long bottom shaft will serve for all three heads. The gauge of centre to centre of each delivery to be taken at 16 inches, requiring in one case 30 feet $7\frac{1}{2}$ inches in length over all. This is for the usual six ends up behind each head. Single boss top rollers to be used and to be leather covered, with loose end bushes and not loose bosses. These machines are for ordinary staple middling American cotton, and will take roller dimensions as given below. Top rollers all four lines to be $1\frac{1}{8}$ inch diameter before leather and flannel coverings are applied. For the bottom rollers $1\frac{3}{8}$ inch diameter for all lines excepting the second from front, which may be $1\frac{1}{8}$ inch diameter. Case-hardened all over front line of bottom rollers and the other three lines case hardened only in necks or bearings. The draft rollers should be capable of opening out to the limit of $4\frac{3}{4}$ inches or 5 inches, and of closing in so as to be almost touching if shorter staple than average happen to be used. This is a question which also affects the clearer arrangements, as some kinds of clearers require adjustment in proportion as the rollers are opened or closed. Top rollers to be dead weighted with hooks at each end of the rollers, and fitted with dead weight relieving motion for use during long stoppages. The weights may be in this case 20 lb. on the front line, and 18 lb. on each of the other lines, this amount of weight to serve for one end only of any one roller. As in the case we are only proposing to run the front bottom rollers at the speed of 330 r.p.m., with a diameter of $1\frac{3}{8}$ inch, we need not specify any spiral springs for the weights to reduce vibration. The sliver cans must be of the usual or standard dimensions, 36 inches length × 9 inches diameter inside dimensions. There will be six back cans, and therefore six back slivers for each top roller boss. It is intended to use a hank sliver ·180, which will equal 46·29 grains per yard, and this will be a guide in regard to one or two details of construction. Arrangements to be made for usual back and front stop motions, and also for full-can motion, all of the ordinary mechanical or speed-lever type, the full-can stop to be on the measuring motion principle, giving an exact length of sliver in each can, and capable of wheel alteration if the weft per yard of sliver were ever altered. The total roller draft will be approximately six, divided out as near as convenient to give intermediate drafts of $1\frac{1}{4} \times 1\frac{3}{4} \times 2\frac{3}{4}$. Naturally the diameters of the rollers will affect this, and it will not always be easy to apply wheels which give exact middle drafts balanced to 100th part,

It is intended to have every three heads zigzag, with the chief driving pulley at the end of the long bottom shaft at the right hand of the machine, assuming a person to be standing in front of the delivery side and facing the coilers at the first head or passage. The first small driving belt will be on the left hand, the next one on the right hand of its own or middle head, while the last or third small belt will be on the extreme left hand of the three heads. These little matters require to be clearly understood by both maker and user of machine, and yet it is easy to get a little mixed up on some points, so it will always be best to give a plan showing the relative positions of all the pulleys specified, this being an exceedingly easy thing to do. The whole of such a frame, including all the three heads, could be spoken of as a right-hand frame, and each head spoken of as being "left" hand or "right" hand, just as the little front roller pulleys happen to be on the person's left or right. One of the points affected by such considerations is that of the draft wheels required on the different heads and frames. We have previously given a front roller speed of 330 per minute, and this speed naturally affects the size of chief driving pulleys. Dimensions of pulleys may be as follows: 18 inch driven pulley on the long under shaft. On same shaft a 16 inch pulley driving a 10 inch on the front roller. From these dimensions we determine the revolutions of under shaft as follows:—

$$\frac{330 \times 10}{16} = 206{\cdot}25$$

Assuming now the top line shaft to make 250 r.p.m. we find diameter of line shaft drum as below:—

$$\frac{206{\cdot}25 \times 18}{250} = 14{\cdot}85 \text{ inches.}$$

or say 15 inches diameter to allow of a slight amount of slippage in the two belts which drive the front roller from the line shaft. Pulleys may be specified as indicated by these calculations.

Coming now to the kind of clearer to be employed, we will specify Ermen's positively driven, self-clearing revolving flannel, even if extra must be paid for it. We do not need fast and loose pulleys and strap fork on the under shaft, and will have this shaft well guarded and covered. Ordinary plain strap forks for the front roller belts. If possible we will have the can box let into the floor about $2\frac{1}{4}$ inches to keep the height of frame as low as possible. We will not apply indicators for wages to any of the heads, but will make any calculations required according to the productions and indicators of the slubbing frame and intermediate. Neither will we apply taking-in rollers behind the machine any further than the usual preventer rollers and these we will specify as being now

practically indispensable. We prefer to have locking motions to the covers of the calender roller and draft roller wheels, and these are to be specified. As regards the covering of the top rollers and top or bottom clearers we will have these delivered in a finished condition ready for working. We prefer to apply a roller traverse motion, and the ordinary one will serve the purpose without any special patent or device. We propose to work middling American cotton of 1 inch to $1\frac{1}{8}$ inch staple, and make a hank sliver ·180 for counts of roving $5\frac{1}{2}$, and counts of yarn single roving 40's or 42's average.

Settings and Drafts for Dhollerah, Texas, Brown Egyptian, and Sea Islands Cotton.

There are several fundamental principles which chiefly regulate the distance apart of the drawing or "draft" rollers in a spinning mill: (1) The distance from centre to centre of front and second rollers should always slightly exceed the length of the cotton fibres, say by $\frac{1}{32}$ of an inch. This applies more particularly to the front and middle rollers of the mule or ring frame. (2) When there is a very small draft the rollers can be farther apart, as between the back and middle rollers of the various machines. (3) The thicker the body of fibres operated upon, the farther apart should the rollers be. Because of this the rollers in the card-room are set a greater distance from centre to centre of adjoining rollers than the corresponding rollers in the spinning-room. The greater diameter of the rollers to some extent compels this. Coming, then, more particularly to the draw-frame, for good Dhollerah we might have the first, third, and fourth rollers $1\frac{1}{8}$ inch diameter, and the second roller 1 inch diameter. A good working distance between the leathers of the first and second rollers would be $\frac{1}{16}$ of an inch or so, and between the other lines of rollers we might have the same or a little greater distance. The total draft would be about six, as doubtless six ends would be put up together. This total draft might be split up as follows: Between first and second rollers, 2·86; between second and third, 1·71; and between the third and back rollers, 1·22.

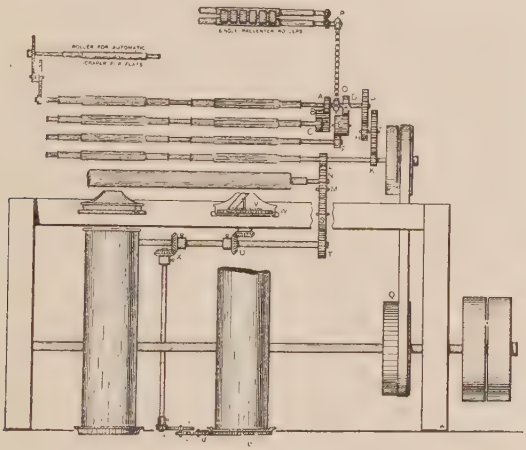
Proof:—

$$\frac{6 \text{ total draft}}{1{\cdot}71 \times 2{\cdot}86} = 1{\cdot}22.$$

For American cotton, such as Texas, it is usual to have the rollers larger in diameter than as given above for Indian. Sometimes dimensions are $1\frac{3}{8}$ inch diameter for first, third, and fourth iron rollers, and $1\frac{1}{8}$ inch for second roller. Something a little more or less than $\frac{1}{16}$ of an inch space might be allowed between the various lines of rollers, the wider distances being usually reserved for the back rollers. The drafts for Texas might be as given for Dhollerah.

or a little varied therefrom. In many cases the rollers are $\frac{1}{8}$ inch less diameter that as above given for American.

For Egyptian and Sea Islands we could have the diameters of the rollers as given for American, or, say $1\frac{1}{2}$ inch for the first, third, and fourth rollers, and $1\frac{1}{4}$ inch for second roller. There might be a space of $\frac{1}{16}$ to $\frac{1}{8}$ of an inch or more between the various lines of rollers, according to the diameters of the rollers and the length of the cotton. If six ends were doubled the drafts might be as given above for Indian and American. If eight ends were doubled the drafts might approximate to the following: 3·12 between first and second lines, 1·95 between second and third lines, and 1·31 between third and fourth lines.



DRAWING FRAME GEARING

WITH ROLLERS GEARED AT ONE END ONLY

Fig. 37.

Proof:—

$$\frac{8 \text{ total draft}}{3{\cdot}12 \times 1{\cdot}95} = 1{\cdot}31.$$

The drafts for all these cottons might be the same in each of the three heads of drawing usually employed.

It may be added that an approximately correct *rule for apportioning the drafts* of a draw-frame is as follows: (1) For the middle draft of the three, extract the cube root of the total draft. (2) Extract the square root of the middle draft thus found for the back draft. (3) Divide the product of the two drafts thus found *into* the total draft in order to find the front or delivery draft.

For example, take a case where eight slivers are doubled together and a total draft of eight is required :—

(1) $\sqrt[3]{8} = 2$ = middle draft.

(2) $\sqrt{2} = 1{\cdot}4$ = back draft.

(3) $\frac{8}{1{\cdot}4 \times 2} = 2{\cdot}86$ front draft.

Such rules as above are of little practical value. It is better to memorise or note actual good conditions for six or eight ends up.

Example for six ends up : $1\frac{1}{4} \times 1\frac{3}{4} \times 2\frac{3}{4}$ approximately.

Clearers for Draw-Frames.

It is necessary at practically all the machines in a cotton-spinning mill containing draft rollers to provide clearers for both top and bottom rollers—at any rate as regards the front lines. At no machine is this problem of greater importance than at the draw-frames, owing to the fact that a very thick body of cotton fibres is constantly passing through these rollers, and the cotton is also in a very loose condition, there is more work for the clearers at the draw-frame than at any other machine. A draw-frame is an exceedingly productive machine—on occasions passing as much as a thousand pounds of sliver per week into one can—and there is no twist in the sliver except the very small amount incidentally put in by the rotation of the top coilers or tube plates.

The ordinary cloth covered stationary flat appears to be deemed good enough by many users of American cotton, but for Egyptian cotton most firms appear to want something more effective. Not only is there a greater proportion of cotton fibres below the average length in Egyptian cotton, and therefore there is a greater tendency for making bad ends or slubs at the draw-frame, but also the presence of bad ends more greatly depreciates the value of the better and finer sorts of yarns. For such finer and more highly priced yarns it is essential to pay the utmost attention to any details which more or less affect the quality, and this idea has something to do with the greater attention bestowed upon the question of clearers. We have stationary flat flannel-covered top clearers, revolving flannel top clearers used without automatic cleaners or special driving gear, Ermen's top clearer in which there is used an endless revolving flannel clearer fitted with both special driving gear, and also with a scraping and automatic cleaning apparatus ; there are flannel-covered clearers revolving in a circle like a top spinning over the rollers ; there are round clearers working by frictional contact ; round clearers driven by gearing at a positively controlled speed, and round clearers connected by spindle banding or small belts. Three or four of these may be at once distinguished

as receiving more present-day adoption than any of the others. For American and Indian cottons the ordinary stationary flannel clearer is very much in vogue, being the simplest and cheapest form of all.

For Egyptian cotton many prefer a more elaborate form of clearer, and very largely divide their preference between the positively driven roller clearer and the Ermen clearer, both of which are very effective if properly worked. It is very important that the small mechanical details of these be kept in good condition, and that the draw-frame tenters be taught to efficiently handle the clearers.

Briercliffe's vibrating under clearers have been applied at many spinning firms to draw-frame rollers.

Clearer Waste.

This is a much inferior class of waste to the comber waste. It is the usual practice to have flannel-covered clearers of one type or another to rub against the top leather-covered rollers of the various machines in order to lick up the bits of fibre and prevent roller laps and bad ends or slubs. To a somewhat less extent it is also the practice to use clearers for the bottom rollers of the various machines, more especially for the front bottom rollers.

To examine for a moment the flat waste or clearer waste from draw-frames and fly-frames, this presents for the most part a choppy, lumpy, detached appearance exactly opposite to that of comber waste. For the most part flat waste is composed of short bits of fibre that become detached from the body of the cotton, stick to the roller, and are then attracted to the flannel of the clearer. This waste also often contains a fair amount of fine sand or other small dirt which has escaped the previous processes, especially if combers are not used. Its choppy appearance is partly due to the frequent picking of the clearers which is found necessary in the card-room in order to limit the number of bad ends.

On a draw-frame the question of the clearers, both top and bottom, has been often a very burning one, and especially so in fine spinning, where "slubs" are considered a very great evil.

Terms in Use for Draw-Frames. Productions.

The term gauge is sometimes taken to mean the distance from centre of one can to the centre of the next one. In other cases it means the distance from centre to centre of two roller stands. In this connection we may quote the words of an important firm, who say, "Our standard box or gauge is 16 inches. We sometimes make them 13½ inches gauge where very small diameters of fluted and top rollers are used, because under these conditions it is necessary to use heavier weights, and there is thus a greater liability for

the rollers to spring, which is reduced by using the narrower gauge. It is mainly on this account we do not advise a wider gauge than 16 inches. We also make frames with 17 inch or 18-inch gauge."

By the term "number of ends up" is meant the number of back slivers which are used to form one front or delivered sliver, six ends up being most common, eight ends coming next, and often in use for fine counts. There are cases of four ends up, five ends up, and seven ends up, and generally speaking it is customary to have lower numbers of doubling for the coarsest work.

By the term "head" is meant the arrangement for one passage of cotton through the machine, or one set of deliveries as governed by one small frame strap. It is a rather curious and not always clearly understood expression. If we say a draw-frame of three heads and six deliveries each, we mean there are three separate frames, each containing six front cans, each independently driven by a small belt working on the front roller pulleys, and each capable of stopping or working without the others. The same cotton passes through each one of the three frames in succession, and therefore there are really only the six front cans of the third or last frame or head which actually count for production. Although there are eighteen front cans to be attended to, it is only the last six which pass forward to the slubbing frame.

In regard now to productions those at the draw-frame are usually quoted at so much per finishing or third head delivery. One firm gives approximate productions in the following table, made out per day of ten hours :—

Indian cotton	160 to 177 lb.
Russian and American cotton .	124 ,, 159 ,,
Egyptian cotton . . .	62 ,, 120 ,,
Sea Islands cotton . . .	39 ,, 62 ,,

Another firm quote production for a full working week for given hank slivers and weights of 5 yards in grains, and two or three are given as follows : ·120 hank sliver, 347·2 grains per 5 yards, productions from 952 lb. to 1,370 lb. per week ; ·150 sliver, 277·7 grains per 5 yards ; 761 to 1,095 lb. per week per delivery ; ·250 hank sliver, 166·5 grains per 5 yards, 457 lb. to 653 lb. of sliver per delivery per week.

Details of Draw-Frames and Maker's Statement.

"Improved drawing frames, made from two to ten deliveries to each head, 15¾ inch, 17 inch, and 18¾ inch staff, with mechanical or electric stop-motion. Main improvements and general construction as below : roller beam, planed and polished, is made exceptionally strong, and of sufficient width to carry calenders as well as rollers without requiring supports at the ends of the stands. The

roller bearings are milled, and all attached surfaces are planed or milled, so as to render the parts interchangeable without filing or other fitting. All draft wheels have teeth cut out of solid, and only one wheel requires changing when an alteration in the draft is required, all the intermediate drafts being at the same time changed in proportion. Stands with wide roller bearings bushed with brass, and each line of rollers can be adjusted separately. All bottom rollers made in own works, and are of superior quality. Top rollers made with one or two bosses for each delivery, weighted by levers or dead weights, and either each line separately or two lines together. Rollers with two bosses can be weighted in the middle or at ends or both. Roller gearing well guarded, placed all at one end of each head, or at both ends. Mechanical stop-motion. Own double-action stop-motion recommended, being simple, and yet so sensitive and accurate in its working that the frame is practically stopped instantaneously when an end or sliver breaks. Electrical stop-motion if desired. Iron flats over rollers with stationary cloths, and clearers under all four lines of rollers supplied with all frames, unless some other style of flats is preferred. Can frames for 9 inch, 10 inch, or 12-inch diameter of cans as required, and made for sinking in the floor. Driving pulleys arranged for 3 inch, $3\frac{1}{2}$ inch, or 4-inch straps as desired. Drum on bottom shaft 14 inches, 15 inches, or 16 inches as desired. Height of frame to top of flats 3 feet $8\frac{1}{2}$ inches = 1·13 metres."

The following extras and improvements can be supplied: "Mechanical stop-motion for front as well as back; electrical stop-motion back and front; arrangement to double eight ends into one instead of six; guide rollers at back, with top roller, i.e. single preventer, sliver roller at back, the same as in slubbing frames; iron flats over rollers with revolving clearers, or with automatic scrapers (Ermen's system); loose boss top rollers, or loose cast-iron bushes on ends of top rollers; fluted bottom rollers, case hardened throughout or only in the necks; metallic rollers; weight relieving motion, to take the weight off the rollers when the frame is standing; ordinary traverse motion, or Tatham's double traverse guides; automatic motion to stop frame when cans are full; indicator, strap fork, and guide over driving pulleys; cover over bottom shaft all along the frame; ring bearings (Mohler's system) for bottom shaft. Frames can be arranged to have passages between the heads, with the bottom shaft going through and covered in passage."

Draw-Frame Stop-Motions.

Every draw-frame is fitted with an automatic stop-motion of great usefulness, which causes the frame to automatically stop upon the breakage or failure of any one sliver at practically any part of its progress from the feed cans to the delivered cans of sliver.

These automatic stop-motions are divided into the two kinds, electric and mechanical or spoon lever stop-motions, both of which are very extensively and very successfully used.

The electric stop-motion is of more recent application than the mechanical arrangement, but the latter is preferably made by most of our great machine making firms, according to the requirements of their customers. In the case of the electric stop-motion, a weak current of electricity is generated near the machine by a small dynamo, and conveyed to the machine by the usual insulated wires. In a manner of speaking the draw-frame is divided into two parts, one part being connected with the positive and the other connected with the negative pole of electricity. Cotton as passed through our spinning machines is an effective insulator, and is used for that purpose in connection with the electric stop-motion. The greatest example of the particular use of this stop-motion, and the one which lends itself best to explanation, is in connection with the feed of the back slivers. Each sliver passes between a pair of preventer rollers, the upper one of which only serves for two slivers. The top roller belongs to one electrical pole and the bottom roller to the other pole, the slivers keeping these two apart. Assuming that a back can runs empty or breaks, then one end of the short top roller drops into contact with the bottom roller and allows the electrical current to complete its circuit. In a most ingenious manner, advantage of the flow of electricity is taken to liberate a stop catch, unlatch the stop rod, and place the belt upon the loose pulley. A small magnet becomes momentarily charged with electricity, and at once attracts a pendulum catch into the path of a revolving roller so as to stop the said roller. This roller is driven through the medium of a small incline which now causes a sliding action of the unlatching mechanism, so as to unlatch the spring rod and move the belt upon the loose pulley. A front roller lap, a front can becoming sufficiently full of sliver, or failure of a delivered sliver to pass between the two calenders, would lead to electrical contact and stoppage of the frame.

Mechanical v. *Electrical Stop-Motions for Draw-Frames.*

Several defects may occur on a draw-frame with an electric stop-motion—which have a tendency to produce uneven slivers. In a draw-frame with an electric stop-motion, the sliver being fed into the machine goes up to the rollers in a kink or knot, and the sliver in bunch form is drawn under the detecter and stops there, thus preventing a contact which is necessary to stop the frame. Sometimes this bunch passes between the draw rollers, eventually choking the trumpet at the front, and in case the trumpet has rather a small hole the calenders do not break the end short enough, thus allowing a portion of sliver to be suspended between the calenders :

therefore it is obvious the calenders will be prevented from making a contact, making an unnecessary amount of waste, unless the tenter happens to be on the spot. The above defect is not possible when the ordinary spoon motion is used, for should the sliver happen to stop between the preventer rollers in a knot or bunch, the resultant breakage of the end between the preventers and back draft rollers will allow the spoon to rise and stop the frame. Then again, supposing the knot or bunch passes the draw rollers and chokes the trumpet in the manner above described, it will be seen that the calenders continuing the pull at the sliver will cause the lever supporting the trumpet to depress, and thus act on the stop-motion, and cause the frame to be knocked off without making much waste.

In a draw-frame fitted with the electric stop-motion, slivers may pass into the draft rollers which are only half of the standard weight, three or four slivers may lap around the back or middle rollers, and still the frame continues to run. A soft piecing made at the card is drawn out owing to the slight draft between the back draft rollers and the electric rollers. When this happens the electric roller combines to pass the sliver forward, and this sliver instead of passing through the draft rollers, gathers in a heap on the plate supporting the electric rollers, and therefore the sliver delivered in front will be deficient in weight. When any of the above defects happen on a frame fitted with the mechanical stop-motion in proper working order, the machine is promptly stopped. There are several causes which go towards making bad slivers which a carder never sees, although he knows it is possible for them to exist. A frame with an electric stop-motion gives an unscrupulous tenter a better chance of running the frame when she thinks there is a sliver missing at the back.

The Full Can Stop-Motion.

The mechanism operates in one case, on the well-known Hunter cog principle. A pinion wheel on the end of one of the front calenders drives a larger wheel revolving loosely upon a stud, and compounded with the second wheel is a worm which gears with and drives two thin worm wheels simultaneously. The two worm wheels work independently side by side, and each carries a small stud or snug on its outer side. One wheel may contain 49 teeth, and the other 50 teeth, and assuming the wheels to start off with the two studs level, it will take 49 revolutions of one wheel or 50 of the other before the two studs come level again, a feature which is necessary before knocking-off can happen. There are two small pendant latch levers each independently holding up a long trip lever which can therefore only be released when both pendants are moved away together. Every revolution of either the 49 or the 50

worm wheel moves one pendant latch away, but nothing further results until both studs come together after 49 revolutions of the 50's wheel and 50 revolutions of the 49 wheel, when the two pins or studs come level and move both pendant catch levers away simultaneously. Then the long trip lever is allowed to drop into the path of a connection of the rocking knife bar at the back of machine, and release the belt rod as explained for the fall of a back spoon lever.

Taking approximately correct working dimensions, we will assume a 16's pinion fastened on the end of a calender of 3 inches diameter, and driving a 32's stud wheel. Compounded with the 32's wheel is a single worm driving two worm wheels containing respectively 49 and 50 teeth. How many yards of sliver will be put into each full front can, remembering that one such measuring motion serves for all the front cans on one machine and controlled by the same back stop-motion?

Solution :—

$$\frac{3 \times 22 \times 32 \times 49 \times 50}{7 \times 16 \times 1 \times 12 \times 3} = 1283\tfrac{1}{3} \text{ yards.}$$

By altering one or both of the pinions a different length of cotton can be put into each can.

Alternative Eccentric Stop-Motions.

There are alternative or other arrangements for stopping a draw-frame depending upon the basis of an eccentric and eccentric arm. In one successful combination the eccentric arm is weighted at the end farthest from the eccentric so as to rest somewhat solidly at the bottom of a V-shaped or triangle double slot, forming the lower end of a lever which has its upper extremity working just beneath the tails of the various spoon levers. The lever is of the first order, and is reciprocated by the movement of the eccentric exactly after the manner of the elbow lever in the motion described at the beginning, but the V-shaped double slot takes the part of the elbow. Assuming now that a back can runs empty of sliver, then its spoon lever will fall into the path of the reciprocating bar and arrest its movement. The continuing rotation of the stop-motion eccentric will immediately compel the stud in the weighted out end of the eccentric arm to mount one of the two inclined slots in the V-shaped lower end of the rock-lever, with the result that a trip lever is moved so as to release the sliding spring bar connected with the belt rod, so the belt is at once moved upon the loose pulley. An excellent feature of this double incline stop-motion is that it at once stops the machine whether the eccentric arm is moving either one way or the other, since one of the inclined slots is available for

the mounting of the stud in the weighted end of the eccentric arm whichever way the arm may happen to be moving. Extreme promptness is required in the stop-motions of a draw-frame, and this little feature is of value because it tends to improve the motion in this particular respect, without adding to the cost or complication of the machine. A mechanical stop-motion may be termed double-acting, either because it will act for both light and heavy slivers, or because it will act whichever direction the eccentric arm may be moving.

Electricity Supply.

This note is in connection with the supply of electricity to draw-frames, without the use of the "Magneto machine," as at present used for that purpose. This system has been found to give highly satisfactory results in certain Continental mills, and is becoming a growing custom amongst those who become acquainted with it. It must, however, be distinctly understood that in every case where this system has been instituted the mills have used it as a lighting medium. It would, therefore, only apply to those in this country, who have the town's supply of electricity, or those who produce their own for lighting up some part of the mill. The reasons which led to this system being adopted abroad were important ones when duly considered. It meant in a particular case that some sixty odd small magnetos were ordinarily to be supplied with the drawing and intermediate frames to supply the necessary current. To leave out of the question altogether the first cost of these machines, it was recognised that they would each require a certain share of attention for oiling and cleaning, and occasional adjustment of the driving belts, added to which any deterioration which might set in at a later date, due to wear and tear. There were two alternatives which offered themselves in turn in preference to the above, one of which was to use only one or two magnetos of larger size, and to convey the current to the different machines through special rods. Both of the above systems have their particular adherents, many preferring the latter system to the former, but this system was also discarded after due consideration; both had to give way to a principle at once simple but highly efficient, and which discarded magnetos altogether. The means employed was to substitute for the magnetos two small transformers, commonly called "coils." Now, to the uninitiated, it is as well to briefly explain that a transformer affords a simple means of reducing a current of electricity from high to low voltage, that is to say, for instance, that by its use a current of 110 or 120 volts may be reduced to a current of, say, 8 volts, or again, a current which was of the necessary voltage suitable for electric light, this could be

utilised and reduced to a current suitable for use in electric drawing-frames, which was done in this particular case. The advantages of using transformers for this purpose are, that they do not revolve, neither do they deteriorate with use, they are thus practically everlasting, and require absolutely no attention whatever, moreover they give a sure and steady voltage, which is always maintained since there is nothing which can possibly get out of order. No special rods are required to convey the current to the different heads of drawing, ordinary insulated copper wire such as is used for lighting purposes is all that is needed, and is not only less unsightly than $\frac{3}{8}$-inch iron rods, but less likely to get out of order. It will be fully understood from the explanation given above that the wires of higher voltage, say 110 volts, are led to and connected up to the transformer, the electricity in passing through the transformer issues at a low voltage, and is carried away by wires and distributed to the different machines. The mill where this system was first instituted was driven entirely by electricity, and this greatly affected the initial problem, so that any failure of current which might occur quite obviously affected the whole mill, and caused a general stoppage, but here recognise that in many cases the conditions of a failing current of the town's supply would spell disaster for so long as the current was absent, unless some special provision was at hand to make up for any temporary shortage of current which might occur. In view of this, and in full consideration of such things happening, this ought not to deter the use of transformers here in this country, because for the advantages gained, such cases could be met by having a large magneto (similar to those in present use) fixed somewhere in a suitable vicinity to the main line of the low tension wires.

Can Arrangement.—Cards are seldom fitted with full can stop-motions, but combers often are.

In any case the sliver cans passing from cards or combers to first head of draw-frame are mixed up and are indifferently controlled in regard to yards of cotton in one can being equal to the yards in other cans. The cans should be arranged in three rows of six each if convenient, and will not empty too many at one moment, so that there is little danger of too many sliver piecings coming together, or of frame stopping too long at one time.

Front can stop-motions are customary at each draw-frame so that changing too many back cans at second, third, or fourth draw-frame, may lead to several cans running empty all together, rushing the tenter, causing sliver piecings to come together. To prevent this, sectional feeding and arranging of the cans is insisted on in some firms so that cans will run empty about one time. For example there might be $\frac{1}{4}$ full, $\frac{1}{2}$ full, $\frac{3}{4}$ full, and almost full cans in different sections at one time. Stop-motions should be kept in

good working order, wheels should be correctly geared to ensure smooth and exact working.

Perspiring hands are especially bad at such machines as draw-frames, and the cotton is especially sensitive at passing through the front funnels and slanting tubes.

Sometimes a tenter will be at the trouble to use a hook to draw portions of sliver from the bottom of the can and run these off on top of other cans. Tenters should not be allowed to "skip" frames by using only two passages instead of three, and this evil is aggravated if drafts vary in different heads.

Calculated Production per Finishing Delivery per Ten Hours.

WITHOUT ANY ALLOWANCE FOR LOSS IN STOPPAGES, ETC.

Hank Sliver.	Weight of Sliver per 6 Yards.			Revolutions of Front Roller. 1⅜-inch Diameter.		
				300 Revs.	350 Revs.	400 Revs.
	oz.	dwts.	grains.	lb.	lb.	lb.
·100	1	2	14·5	257·14	300·00	342·81
·105	1	1	14·68	244·89	285·72	326·50
·110	1	0	17·04	233·75	272·71	311·69
·115		18	2·78	223·59	260·87	298·11
·120		17	8·66	214·29	250·00	285·72
·125		16	16·00	205·71	240·00	274·27
·130		16	0·6	197·80	230·64	263·74
·135		15	10·37	190·48	222·22	253·97
·140		14	21·0	183·66	214·29	244·89
·145		14	8·82	177·34	206·88	236·44
·150		13	21·33	171·43	200·00	228·48
·155		13	10·58	165·90	193·54	221·19
·160		13	0·50	160·71	187·39	214·29
·170		12	6·0	151·23	176·46	201·68
·180		11	13·77	142·86	166·67	190·48
·190		10	23·15	135·34	157·89	180·45
·200		10	10·0	128·57	149·98	171·41

If front roller 1¼ inch diameter, multiply above productions by ·90.
" " 1½ " " " " " " 1·09.

If 2 deliveries per head, deduct 8 per cent. from above productions for loss in stoppages, etc.

3 " " " 12 " " " "
4 " " " 15·5 " " " "
5 " " " 19 " " " "
6 " " " 22 " " " "
7 " " " 25 " " " "
8 " " " 27·5 " " " "

Uneven Work from Draw-Frames.

The first thing to inquire into is the uniformity of the laps from the finisher scutcher, both as regards weight of full laps and weight yard per yard of the lap. If this is found to be sufficiently wrong it will be requisite to trace the cause. Very probably this will be found in something belonging to the piano feed regulator, such as dirtiness of the parts, something having worked loose, or slackness and slipping of the cone drum belt.

It may be caused by the scutcher feed motion, or possibly by the opener feed regulator.

Again, such unevenness has often been traced back to the hopper feed.

Providing the lap is right when it leaves the finisher, it is probable that the sliver will reach the draw-frame in a sufficiently uniform condition to make us conclude that the irregularity is caused in the draw-frame itself, although it is sometimes caused at the comber when the latter is used. At the draw-frame a great cause of irregular work is the imperfect action of the stop-motion, and the various parts should all be tested and carefully watched to detect such imperfect action. Sometimes irregularities can be traced to defects in connection with the drawing rollers.

If uneven work passes forward beyond the draw-frame it is almost certain to give yarn that is irregular in counts. When the cotton is uneven in length it is difficult to get uniform drawing, because the rollers cannot be set to the best advantage for both long and short fibres at the same time. There is a tendency for the short fibres to come out in bunches, and to leave correspondingly thin places of sliver elsewhere.

Big Changes on Draw-Frames.

(*a*) 40's twist to 24's hosiery.

(*b*) 80's Egyptian to 20's Indian Broach.

(*a*) If such change were to be of some permanence it is possible that the quality of cotton would be altered. Supposing cotton of shorter staple be used, then the rollers of the drawing and roving-frames should be set closer together if at all convenient. In many cases of small orders it is quite probable that nothing but the mule or ring-frame would be altered, the various adjustments of twists, counts, etc., being made at the proper places of the final spinning machine. In many cases the cotton might remain the same and the alterations divided out between the drawing-frames, bobbin, and fly-frames, and final spinning machine. Assuming this to be the case, the change pinion for counts on the drawing-frame would require proper alteration, say a larger wheel in proportion to the amount of increased thickness of sliver required at this point. At

the roving-frame several wheels would require to be altered according to well-known rules. The change pinion for counts or hank roving would require making larger in simple proportion to the increase in thickness of the roving. The ratchet or rack wheel would require to be made smaller, while the twist wheel and the lifter wheel or strike wheel would require to be made larger, all three in proportion to the square roots of the rovings previously making and those intending to make. Twenty-four's hosiery would probably require to be of good quality spun from very fair cotton, and because of its soft, clean character the twist would require to be kept down as much as possible, and every care should be exercised to keep the rovings free from motes or slubs, as these are fatal to the processes of hosiery manufacture.

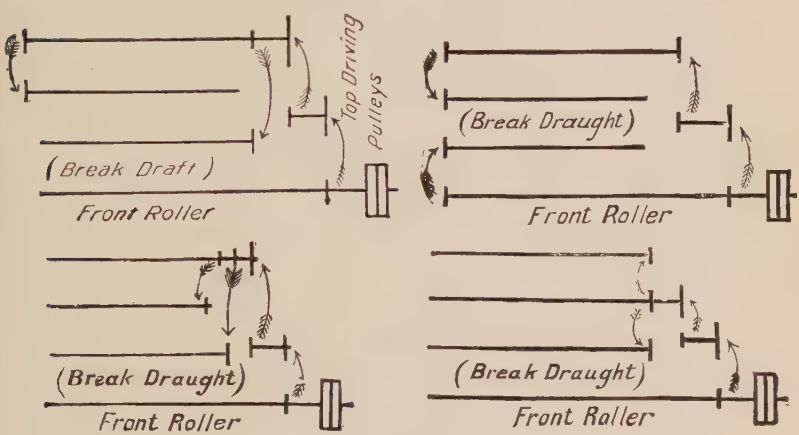


Fig. 38.

(*b*) If eight ends were being put up together for the 80's Egyptian —as is often the case with these yarns—it is very probable that we should make two of the back spoons used for slivers going to each front delivery inoperative. In which case corresponding alterations would have to be made in the traverse guide. If this course were adopted the draft would have to be diminished from about eight to about six. In some instances the full can knocking-off motion has a change wheel used in connection with it, and in such cases this wheel would have to be regulated in size according to the change made in the thickness of the sliver. If the diameter of the sliver were varied considerably, then it is not unlikely that the size of aperture in the front trumpet tube would have to be altered in proportion. Perhaps the most important point to attend to would be the adoption of means by which the rollers could be got sufficiently

close to accommodate the length of fibre. It is common to make the rollers much larger in diameter for Egyptian than for Indian cotton —say, for instance, $1\frac{1}{8}$ inch diameter for front iron roller, and 1 inch diameter for middle roller with Indian cotton, and $1\frac{1}{2}$ inch and $1\frac{1}{4}$ inch diameter respectively for Egyptian. To get the best results, therefore, we should require new top and bottom drawing rollers. The weights on the rollers could conveniently be altered with lever weighting, but with dead weights it is a question as to whether it would pay to get new weights for the slight amount heavier which it is usual to allow for the Indian. Back rollers same diameter as front.

Driving of Drawing-Frame Rollers (Fig. 38).

In an ordinary cotton spinning mill without combing all the machines contain three pairs of drawing rollers, except the draw-frame, in which there are four pairs. Having four pairs of rollers on a draw-frame somewhat complicates the driving, and there are several methods more or less in use. Probably the most common arrangement is the one in which back roller is driven from front and the two intermediate lines from the back line, all at headstock end.

One firm makes any of the four methods shown in Fig. 38, according to requirements. Usually the break draft is between the first and second rollers, but in one case this draft is between the second and third rollers. Having the wheels that drive the intermediate rollers on the opposite side to the driving pulleys, is considered by some to be the most convenient method. The break draft is that which is altered when we put on a different size of change wheel for draft. Many prefer the break draft to be the largest.

Wrapping.—Testing for counts is rightly performed more frequently at the finishing head of drawing than at any other stage in the mill, if we except the somewhat crude method of counts testing by weighing all full laps from opener or scutcher.

At this draw-frame custom varies, but twice daily is often the case for American cotton and three or even four times daily for long staple cottons and fine counts. The treatment of the cotton at each separate head of a comber is not conducive to uniformity in counts, but the invariable use of the comber draw box with six or eight ends up does a lot towards giving reasonably level slivers from the comber. Per yard 2 grains up or down from standard is aimed at in some cases.

For American cotton—and often for Egyptian—it is quite common to use the yard wrap block to measure off 4 or 6 yards of sliver for "wrapping." The same machines serve also for all the fly-frames taking 15 yards slubbing, 30 yards intermediate, 60 yards roving.

	Wheels.	Sizes Made.			
		Rollers $1\frac{1}{8}$″ 1″ $1\frac{1}{8}$″ $1\frac{1}{8}$″.	Rollers $1\frac{1}{4}$″ $1\frac{1}{8}$″ $1\frac{1}{4}$″ $1\frac{1}{4}$″.	Rollers $1\frac{3}{8}$″ $1\frac{1}{8}$″ $1\frac{3}{8}$″ $1\frac{3}{8}$″.	Rollers. $1\frac{1}{2}$″ $1\frac{1}{8}$″ $1\frac{1}{2}$″ $1\frac{1}{2}$″.
A	Back roller wheel to drive 3rd roller	25	25	28	28
B	Carrier for ditto	56	56	56	56
C	Wheel on 3rd roller	18	19	22	22
D	Back roller wheel to drive 2nd roller	45	48	53	60
E	Carrier for ditto	56	56	56	56
F	Wheel on 2nd roller	16	18	20	21
G	Back roller wheel driven from front roller { for draft 6 : 1	60	60	72	72
	{ ,, 8 : 1	66	66	72	72
H	**Change wheel** { for draft 6 : 1	49, 50, 51	49, 50, 51	59, 60, 61	59, 60, 61
	{ ,, 8 : 1	40, 41, 42	40, 41, 42	44, 45, 46	44, 45, 46
J	Crown wheel	100	100	100	100
K	Front roller pinion	20	20	20	20
L	Front roller wheel to drive calender rollers	15 P.10	17 P.10	14 P.8	20 P.10
M	Carrier for ditto	66 P.10	66 P.10	53 P.8	66 P.10
N	Calender wheel	39 P.10	40 P.10	30 P.8	39 P.10
S	Carrier wheel for coiler shaft	57 P.10	57 P.10	46 P.8	57 P.10
T	Wheel on coiler shaft	34 P.10	34 P.10	27 P.8	34 P.10
O	Chain wheel on back roller for single preventer	9 teeth			
P	Chain wheel on single preventer roller	9 teeth			
Q	Drum on bottom shaft	14″, 15″ or 16″ [usual 15″]			
R	Fast and loose pulleys on front roller	10″			
U	Bevels to drive coiler	18	a Wheel to drive can wheels		11, 12, 13, 14
V	Wheel to drive coiler wheel	48	b Compound carrier		48
W	Coiler wheel	94	c Compound carrier		12
X	Bevels to drive upright shaft	18	d Carrier wheel		48, 61, 70, 89
			e Can bottom wheel		102

The extreme productiveness of the draw-frame, dealing with the cotton just before reaching the fly-frames, and the limited number of wheels to be altered, make the finisher draw-frame a favourite and very suitable place at which to test and correct the counts of the cotton. Some firms allow 5 per cent. up or down before altering draft pinions.

In many cases the measuring board is used instead of the yard wrap block. Lengths of 2, 3, or 4 yards are readily measured off for weighing by any simple board. In some cases a folding board is used, exactly 1 yard in length and a few inches wide when closed up. A frame is stopped, all the four or six front cans taken out, and then about $1\frac{1}{2}$ yards or so run through. All the four or six slivers are carefully broken off and laid in the measuring book with projecting ends which are afterwards cut level. Then weigh the slivers in the ordinary way and compare as desired. We may allow on 6 yards, 10 grains up or 10 grains down.

Metallic Rollers.

Metallic rollers for draw-frames, comber draw-boxes, ribbon and sliver lap machines, have been in more or less extensive use for many years.

They certainly save leather, and absence of leather and flannel means that the rollers are not susceptible to any fluctuations of moisture or heat likely to occur in a spinning mill.

With ostensibly the same diameter they give increased drafting power—up to 20 per cent.—over leather-covered rollers, and possibly also an equivalent extra production and need no varnish. They are more initial first cost, occasionally give unexpected results and have always been subject to matter of opinion. Most people in England have always stood by the leather-covered rollers.

Many have contended against them; below is a favourable opinion from one carder.

The idea dates back to 1860, but after lapsing, was taken up again with the addition of true steel collars on top and bottom to work against each other.

Back or feed line is often of coarser flutes than the front or delivery lines.

"Carder" says: "I am of opinion that these rollers are not in any way responsible for uneven drawing when properly set. I minutely examined my 'metallics,' which had been running for eighteen years, and found them in perfect order, and likely to go on giving satisfaction for many years to come. I can say that I have never had any trouble or the least anxiety concerning the work they have turned out. Eight sets gave satisfaction, conclusively proving that the principle of the 'metallic' system is right, and if carders would insist on the rollers, after scouring, being put back

into exactly the same places as they came from, a lot of bad work and anxiety would be avoided."

Weights.—Both dead weighting and lever weighting for top rollers of draw-frames have long been in extensive use. Approximately correct weights for *each* end of *each* top roller may be 20 lb. for Indian, 18 lb. for American, 16 lb. for Egyptian or Sea Islands.

Frequently 2 lb. extra is placed on each end of each front roller, but in some cases this 2 lb. extra is recommended for the second from delivery roller instead of the delivery. Weight-relieving motions may be applied to either dead or lever weighting, and are useful for quickly easing the weight for long stoppages, or for varnishing or for removing roller laps. They are simpler to apply to dead weighting than to lever weighting. Every care should be taken that every weight is always doing its full share and is not disturbed or out of action partially or fully.

Drafting.—Approximately correct drafts for six ends up are $1\frac{1}{4} \times 1\frac{3}{4} \times 2\frac{3}{4} = 6{\cdot}015$ total. These are easier to remember, easier to work other drafts from, and more practically accurate than rules depending upon extraction of square or cube root. Although $8 \times 8 \times 8$ doublings count much higher in doubling value than $6 \times 6 \times 6$, yet the latter has gained in favour even for fine yarns, owing to tenter's work being simpler and drafts lower.

Draw-Frame Rollers.

The central feature of any draw-frame consists of the draft rollers, and everything on the frame is directly concerned with the action of these rollers. Four pairs of rollers are usual, three pairs do not deal effectively with such thick slivers, and five pairs do not appear to be necessary, and would complicate driving materially. They should be maintained in parallel order with each other in all four lines, and the upper with the lower rollers. The distances of the rollers from centre to centre should be correctly adjusted for the kind of cotton used. It is a debatable point as to which top roller on the draw-frame should have the most weight upon it—a question which seldom arises for any subsequent machine since on all fly-frames, mules, and ring-frames it is always deemed best to put most weight on the front roller. Often on the draw-frame the most weight is placed on the roller second from the front, one argument for this being that this roller is required to offer the most resistance to the drafting action. The writer does not attach very much importance to this idea, and would prefer to keep the four lines of weights all alike to avoid any mixing up or possible confusion. The front roller has the most work to do, and if there is any difference in weight this would be a strong argument for weighting it the heaviest. There are some who argue that the back roller

should be the heaviest weighted because it deals first with the thick slivers from the card or comber. One thing is certain, there is no such difference in weighting feasible for draw-frame top rollers as there is on ring-frames, mules, and jack-frames, as between the different rows.

Tenters.

Tenters should make proper piecings end to end, neither dirty, lumpy, nor damp. No sliver can should contain any portions of sliver left unpieced after breaking.

A reasonably smart tenter will often extract the last few layers from a can and piece same on top of next full can, thus saving time in frame running.

Tenters should not be allowed to miss the prescribed picking of clearers, nor in any way to neglect oiling, cleaning, and varnishing.

Sometimes a system prevails of changing so many leather rollers per week, and in other cases the carder or under-carder decides the matter of renewals or extent of varnishing. Fibre cans are now much used and are very light. Tenters should not damage cans in any way if avoidable.

Three heads, six ends up, is far and away the most prevalent system. Egyptian carded often has three heads with seven or eight ends up.

Sometimes four passages of draw-frame are in use, and five have been tried but not found of advantage.

In combing mills there may be one head of drawing before combing, when the ribbon machine is not used, and two heads have been tried. After combing the use of the draw-frame should not be excessive on account of the soft nature of the combed slivers, and the parallelism of the fibres. Uniformity of counts is, of course, highly desirable.

Loose End Bushes to Rollers.

Undoubtedly one of the finest improvements ever brought out in regard to covered top drawing rollers has been the loose boss roller accredited to the inventive genius of Evan Leigh. It is doubtful, however, whether they are considered so paramountly the best thing now as they were from about 1886 to 1906 or so. They are at the present time very extensively and very advantageously used, and especially for the front lines of top rollers in such machines as bobbin and fly-frames, ring-frames, and four or six-thread mule front rollers. However, there are at least three things which have reduced the superiority of the loose boss roller for such large rollers as those used in the draw-frame, ribbon machine, and Derby doubler. In the first place the extensive adoption of metallic rollers has greatly diminished the use of loose boss top

rollers, since metallic rollers are very much used, whatever may be the differences of opinion as to their merits and demerits. In the second place the use of truing up machines, both for the strips of leather before application to the roller, and also for the long rollers after being covered, or after working for a time, has diminished the danger of one boss of a pair being of different diameter than the other. Curiously enough the third reason for diminishing use of loose boss top rollers on draw-frames applies also almost exclusively to machines using rollers of good length and large diameter. We refer now to the loose bushes for covering the ends of the top rollers, combined with the rapid increase in the use of single boss top rollers at the draw-frame.

Loose End Bushes and Middle Weighting.

It is a fact that for something like a century it has been a matter of opinion amongst practical cotton spinners whether it was better to use at the draw-frame dead weighting or lever weighting, and both systems are in extensive use now, and have been for the period named. Dead weighting at any rate appears to be the favourite method for single boss rollers, and there can be no doubt the latter are gaining in adoption. Probably the chief reason for the growing favour of the single boss roller lies in the fact that with the double boss there are four selvedges to each delivered front sliver, as against only two selvedges when the single boss roller is used, and this is an undoubted advantage, because there is always a natural tendency to make waste at the selvedges. The four selvedges, however, are accompanied by the division of one long roller into two half length parts, and formerly this usually meant greater truth in roller diameter, easier roller covering, and each boss able to work to its own independent surface speed, as well as a stationary central spindle which gathers little dirt and requires little oiling. These advantages, however, do not now apply with very great force simply because the loose end bushes so suitable for full-length rollers are often adopted. The loose end bushes for top rollers which are comparatively cheap to manufacture, protect the working ends of top rollers from fly and dirt in a most effective manner, are oiled in the easiest possible manner, maintain the oiled surfaces satisfactorily, and are unbeatable in the manner of permitting top roller weighting with the minimum of friction upon the bearing surfaces. These loose end bushes for draw-frames, helped by the adoption of the full-length roller, have become very extensively adopted indeed.

Improved Loose Boss Rollers.

One of the disadvantages of the loose boss rollers has always been connected with the trouble of taking out the rollers in order

to clean and oil them in whatever machine used. One of our eminent machine-making firms adopted a patent self-lubricating top roller which can be oiled without removing the weight hook. The drawing rollers at any cotton-spinning machine using draft rollers constitute the very life and soul of the machine, since every little bit of cotton is acted upon by the rollers. Consequently it is necessary for the machine makers to make all these rollers in a cylindrical and smooth manner, with means for efficient lubrication, and so that they can be properly weighted. For the self-lubricating loose boss roller referred to it is claimed that all of the following disadvantages of the old style of roller are overcome: "(1) Roller leathers getting oily, thus damaging the yarn; (2) bosses sticking through lack of oil, thus causing friction and cut yarn, besides damaged roller leathers; (3) loss of time and production by having to stop the machines to oil the rollers, and necessitating the removal of the weights; (4) loss of oil as it runs off the spindle on the floor when being oiled. It is claimed that the new self-lubricating rollers possess the following advantages: (1) It is impossible for the yarn to be injured through coming in contact with the oil; (2) perfect lubrication is ensured by means of specially formed grooves, always keeping the oil in circulation; (3) a central aperture and a spiral groove on the spindle ensure the distribution of the oil along the spindle length inside each boss; (4) less oil is required, and oiling can be done with the machine working with all the attendant features of reduced friction, longer life of parts, and smoother working." The author offers no comment.

Four Pairs of Rollers on Draw-Frames.

The slivers are altogether too thick and bulky to permit the requisite drafting out by means of three pairs of rollers. It is quite true that equally thick slivers are used at the slubber, but in this latter case only one sliver is fed for one delivered slubbing end, whereas the most common practice of all is to feed six back slivers to the draw-frame rollers to produce one elongated front sliver. Even with four pairs of rollers at the draw-frame we are compelled to keep the total roller draft within comparatively low limits, this seldom much exceeding $6\frac{1}{2}$ for six ends up together, or $8\frac{1}{2}$ for eight ends up behind. It is, of course, well known that four pairs of rollers are also used in the ribbon machine, while there have been many recent examples of sliver lap machines, and draw boxes of combers fitted with four pairs of rollers.

If the rollers are too small in diameter they are handicapped in regard to strength when treating the heavy slivers of a draw-frame, and may tend to spring and even to develop unsteadiness. These defects are especially noticeable in cases of using high speeds

in order to obtain good productions, and may possibly give uneven drafting of the slivers.

As regards binding in the bearings, we are not as much troubled in this direction as was formerly the case, owing largely to the use of loose boss rollers and loose end bushes. If binding does occur the cotton is not drafted out properly, particularly if it be in the front or delivery roller, in which case the cotton will come out in a thicker condition. Nor will the parallel arrangements of the fibres become as perfect as with rollers in proper working order. It is one way of speedily ruining the leather coverings of the top rollers if there is any binding of the rollers in the bearings. When the rollers have their centres too far apart—especially with rollers of small diameter—there is a tendency for fibres to follow round with the top or bottom rollers, instead of all fibres going forward with the body of sliver into the front can. This is one cause of small roller laps, and of slubs or bad ends, and the stray fibres cannot fail to do harm one way or another.

Reverse Feeding of Cotton.

Not only has the railway idea been applied to carding engines, in which the slivers from several cards have been automatically collected together and combined at the railway head of draw-frame, but much the same idea was formerly applied to the delivery of the draw-frame. In England, however, neither application appears to have met with practical success.

The railway draw-frame appears to have been applied about 1820, and its chief underlying principle consisted in automatically collecting the several slivers delivered from the first draw-frame, turning them round at right angles, and without any intermediate handling to pass the five or six slivers through a second set of drawing rollers. Evan Leigh appears to have been somewhat in favour of this particular idea, and lamented the fact that when he wrote his celebrated treatise upon cotton spinning, this railway draw-frame had been almost entirely discarded. His point of view, however, was not so much the question of saving in labour, but that a particular merit of the railway head consisted in the slivers being passed through both sets of rollers without being drawn the reverse way. A moment's reflection will teach us that our present universally adopted system compels the sliver from the card to be presented to the first draw-frame the reverse way from leaving the card; each sliver from the first draw-frame is reversed in feeding to the second draw-frame, and so on, however many draw-frames may be used, the principle being carried forward even to the presentation of the slivers to the slubbing-frame. Whatever be the net effect upon the resultant slivers, rovings, and yarns, the actual fact is that the fibres contained in the various slivers are

turned about time after time, so that what are the heads of the fibres at one set of rollers become the tails at the next set of rollers. The present writer has carefully considered this involved principle, and is of opinion that the present method is the better.

The railway head principle is utilised successfully at the comber draw box, but speeds are much slower here than at the draw-frame. The slivers are turned at right angles after leaving the collecting tins and fibres fed pointing same way.

Mixing Carded and Combed Slivers.

The combed sliver is infinitely softer and weaker than the carded one, and the difficulties at the draw-frame mainly arise from this fact, although a difference is also made by the more parallel condition of the fibres in the combed slivers. Care should therefore be taken to favour the combed slivers in drawing from the cans, and benefit is sometimes found in placing these cans in positions which impose the minimum drag on the slivers. It is no new thing to mix combed and carded slivers at the draw-frame, but the practice has probably been much extended recently owing to the extensive adoption of combers for the combing of the strips from the flats and cylinder of carding engine. The softer comber slivers will adhere more easily to the rollers or to any surfaces over which the slivers have to drag. On the other hand they will draft out in a somewhat easier fashion.

The draw-frame is one of the readiest and most perfect of machines for blending cottons that differ radically in colour, fibre length, cleanliness or other feature.

The author has proved that such differing fibres as $1\frac{1}{2}$ inch Peruvian and $1\frac{1}{8}$ inch Texas can be blended here and then mule spun with "inside" setting and no top middle roller weight. Also different colours of cotton can be blended on a uniform basis to produce a modified effect.

Roller Distances Apart.

When it comes to a question of adjustment of the draft rollers this is a point which a foreman naturally expects to deal with more or less in conjunction with the manager, and having due regard to the length of the cotton fibre. There are two or three important factors to be specially remembered in connection with the adjustment of draw-frame draft rollers. In the first place the top and bottom rollers which form a pair are usually sustained in the same bearings, are adjusted together by the same set-screw, and cannot be independently adjusted. In this particular respect the rollers of fly-frames, mules, and ring-frames differ from the draw-frame, inasmuch as these other machines provide usually for independent adjustment of top or bottom roller. We are not aware that any

particular need has been experienced for the independent adjustment idea being applied to draw-frames, and the present practice helps to ensure that the centres of top and bottom rollers shall be kept one above the other as regards each pair of rollers. An eminent firm of draw-frame makers for Indian and American cotton usually provide for the rollers being opened to $4\frac{3}{4}$ inches as a maximum from centre of front roller to centre of back one, making it permissible to close up the rollers until the centres will be $3\frac{7}{8}$ or $3\frac{15}{16}$ inches. For long-stapled American cotton and Egyptian the rollers may be opened until the centre of the back roller is $5\frac{1}{4}$ inches distant from the centre of the front or delivery roller, with capacity to close up if required until this distance becomes only 4 inches. For the longest of all cotton fibres, i.e. Sea Island, the maximum possible distance from front to back centres is increased up to 6 inches, with ability to close in the rollers until the centres are only $4\frac{1}{4}$ inches apart. The width of the cast-iron clearers for the top rollers is affected by the maximum and minimum distances apart of the centres of front and back rollers, in order to obtain the best clearing effect with the least inconvenience to the draw-frame tenters.

In reference to the distances apart of draw-frame rollers the leading difference as compared with fly-frames and spinning machines is that there is no reason for such variations in distance between back and middle, and between front and middle, as are common on the later machines. On the mule, for example, out of a total of 12 roller draft for fine counts Egyptian cotton, only 1·08 or so may be put between back and middle, and this leads to close setting between front and middle, and wide setting between back and middle, there being often as much as half inch or more difference between the two. On the draw-frame we might for the same counts of yarn and kind of cotton use distances somewhat as follows: $1\frac{9}{16}$ inch back distance, $1\frac{5}{8}$ inch middle distance, and $1\frac{3}{4}$ inch front distance, these being from centre to centre of roller in each case. Speaking generally the amount of draft between any two pairs of rollers exercises a great effect on their distance apart, ranking next in importance in this respect only to the length of cotton fibre, and even coming first in the case of a fine spinning mule.

Preventer Rollers.

We have before stated that the tension drafts need careful checking in starting a new draw-frame, and unfortunately these low tension drafts are affected by the density and counts of the sliver. In many cases the preventer rollers now consist of two plain bottom rollers, and if the alteration of one of the wheels that drive these preventers will not give the exact amount of tension draft required, then it may be occasionally deemed advisable to turn a very slight amount off the diameter of these preventer rollers,

although it is obvious such a course should not be resorted to until other methods of correction have been unsuccessfully attempted. By driving the preventer rollers from the back draft roller it is ensured that any change in the draft pinion will equally affect the speeds of the back draft roller and of the preventer rollers so as to keep the tension draft correct. A slight tension draft at this point greatly helps in keeping the spoon lever of the stop-motion properly held down by the sliver, and thus secures more perfect action of the stop-motion, whereas with slack slivers there would be a danger of spoon levers lifting up, and stopping the machine when all the slivers were passing forward in the orthodox manner.

Faults in Draw-Frames.

When drawing rollers are too closely set there is often a tendency for the cotton to offer too much resistance to the drafting effect of the rollers, and then portions of cotton to come out lumpy or insufficiently drawn, giving the effect often termed in mill parlance "spewing" of the rollers.

(*a*) When rollers are too widely set there is a tendency for the drafting to be done more or less irregularly, and the sliver to present a somewhat irregular appearance, and for the wrappings to vary somewhat.

(*b*) As regards badly geared draft rollers, if two of the usual four wheels for driving the back roller be geared in too thin or shallow a manner there will be a tendency for some teeth to be missed, and for all the rollers, excepting the delivery pair, to lose so much speed, with the net effect of increasing the total roller draft to the extent of the slippage, but giving at the same time a choppy or very variable effect. Some short portions of sliver might be correct in counts, others rather too fine, and other lengths much too fine, in proportion to the amount of slippage at any period. It might be possible to gear the draft rollers so very shallow as to cause the back rollers to stop altogether, with a very manifest effect.

(*c*) Neglect in oiling the rollers. Perhaps this is likely to show up most in regard to the front rollers, because these revolve the fastest and do the most drafting work. If the front top rollers were stiff for want of oil they would slip and give an insufficient drafting effect, which would result in the sliver coming out insufficiently drafted, this being probably evidenced by the wrapping at the draw-frame or a later machine. A back top roller sticking would give the opposite effect.

Faults in Roving-Frames.

The roller traverse is often set to work too much towards one end of the rollers, with the result of rovings running off the ends of

the rollers. If only a very few rollers are guilty, separate adjustment may be sufficient, but if the defect applies to very many of the rollers an adjustment may be made at the motion itself. Sometimes a traverse spring is slack, or some part is slack or sticking, so that the traverse motion remains almost or nearly stationary, with the result of channelling the rollers and giving imperfect drafting of the rovings. A very short uniform traverse may produce a milder form of the same defect.

(*a*) Sometimes dirt gathers in the slots at the spindle points, and prevents certain flyers from being as low as they should be and causing the rove to build on a rather different portion of the bobbin. If the flyers are insufficiently smooth in the interior of the hollow leg or at any point touched by the cotton, extra drag will be put on the roving, and tend to produce a softer bobbin. Bent or strained pressers or flyers may tend somewhat in the same direction, especially as such flyers may cause vibration in the spindle, which is of itself an evil. The remedies for the foregoing defects are sufficiently obvious.

(*b*) Perhaps the most common faults in the cone belt are slackness and excessive breakage. If the belt breaks the ends all wind slack upon the flyer tops because the winding-on will be stopped and spindles and bobbins will make the same number of revolutions. A slack cone belt may result in a more or less irregular slackening of the rovings, or it may develop in the more dangerous running off at the ends of the bobbins owing to the loading of the lifter at the change imposing extra work on the cone belt. Extreme tightness of a cone belt may lead somewhat in the same direction owing to dilatory response to the lateral traverse at every reversal of the lift. Lumpy piecings in the cone belts may show up in a slightly jumpy action of the rovings.

Front Trumpets.

Brass front trumpets were formerly common but soon showed evidence of wear so that iron trumpets came more into favour. In many cases aluminium spoons have now been adopted. The light hard character of aluminium spoons or tumblers has led to their very rapid adoption, and they can be very sensitively balanced. Double-acting stop-motions are now in common use, and will stop a frame promptly whether the eccentric arm is moving backward or forward. The front trumpets have apertures usually about $\frac{1}{8}$ inch for fine slivers, $\frac{3}{16}$ inch for medium, and $\frac{1}{4}$ inch for coarser work. Too small an opening causes frequent stoppage of work through choking up, while too large a trumpet pole allows bad ends to pass forward, so that it is quite an important detail to gauge these apertures accurately to particular mill conditions.

Spoon levers should drop promptly when a sliver fails or comes

along very light. Dirty, wrongly balanced spoons are troublesome and ineffective.

Later on we refer to the fact of long piecings at fly-frames being drafted out to considerable lengths at the mule or ring-frame. Much more is this so if single on the one hand, or long over lap piecings on the other hand, are produced at the draw-frames.

CHAPTER IV.

SLIVER AND RIBBON-LAP MACHINES. THE HEILMANN COMBER AND ALLIED PROCESSES.

The Preparation of Comber Laps. Cotton Combing.

THERE are two rival methods of preparing laps for the comber, or in other words, treating the sliver from the carding engine so as to put the cotton in the best condition for obtaining the maximum benefit from the combing machine at the least trouble and expense. The older method is to pass the card slivers through a special head of draw-frame, and then to make about eighteen or twenty of the drawn slivers into a narrow lap for the comber at the sliver lap machine. The more modern method—and one which has gained rapidly in use—is to pass the card slivers directly through the sliver lap machine, and then to use the ribbon machine for the purpose of doubling six laps from the sliver lap machine into a more uniform one for the comber, using a draft of six in this machine, so that the weight per yard of lap shall be much the same from both machines.

A ribbon machine is practically a draw-frame which doubles and drafts narrow laps instead of slivers. Both machines help to give more uniform laps for the comber, and both do a good deal towards placing the fibres in approximately parallel order ready for the comber. It is not customary to use both the extra draw-frame and also the ribbon machine before taking the cotton to the comber.

If the sliver lap machine is not supplied with uniform slivers, it tends to give uneven thickness in width of the lap. The passage of the thin cotton sheets down the curved front plates at the ribbon machine tends to develop waste if the plates are not kept well polished. There is a tendency for the lap sheets to spread out wider and make bad selvedges on the ribbon machine. The end plates should fit well to the ends of the bobbins during the making of the laps, to prevent bad edges. The usual defects of leather-covered rollers show up unless checked as clearer waste, roller laps, and bad ends.

The Sliver and Ribbon Lap Machines.

Calender rollers play an important part on these machines, in regard to forming a compact sheet of cotton.

The more usual thing is to use a solid calender of about 5 inches diameter, the upper calender of each pair being lever weighted and sustained in vertical bearings which permit the required vertical movement to suit any variations in lap thickness.

Silent Running Fabroil Pinions.

For special positions ordinary cast or even cut metal wheels are apt to be somewhat harsh and noisy in working.

For example, Buffalo hide pinions are sometimes used to drive draw-frames and fly-frames in cases of individual electric driving. Similarly, the Thomson Houston Co. supply silent running fabroil pinions made from specially treated cotton, fully seasoned, and proof against the action of oil, water, heat or cold.

Spur wheels driven by such pinions, as in any such cases as above mentioned, are likely to have a longer life than when driven by metal pinions. This kind of drive is suitable in many cases for reducing a small motor speed of 800 to 1,400 r.p.m. down to a frame shaft speed of 200 to 400 r.p.m., without noise or breakage, and soon giving a fine polish to the large driven wheels.

Like a good many direct individual electric driving applications there may be occasional difficulty in altering speed of machine, and so many prefer to place the small motor drive a yard or so away from the frame shaft and drive by means of pulleys.

Examples of driving by either Buffalo hide pinions or else by fabroil pinions may be found in draw-frames, fly-frames, looms, clipping machines, dressing frames, cop winders, beam warpers, drum winders, plaiters, cloth-looking benches, drying machines and many other machines in cotton mills, bleaching mills, or in mechanics' shops. Combers and lap machines might be thus driven.

As a slight digression the following note is added :—

With the great increase in railway rates, many firms have found it cheaper and more convenient to organise their own motor delivery service. Repair shops are now to be found all over the country in case of breakdown or mishap to the motors. There is the great advantage of being able to load up and deliver goods direct from producer to user in the quickest time.

Width of Lap.—The most common width of lap for the comber is $10\frac{1}{2}$ inches, and this is made by that machine which immediately precedes the comber. If the sliver lap machine precedes the ribbon lapper then the sliver lap makes laps $1\frac{1}{4}$ or $1\frac{1}{2}$ inches narrower to allow for spreading out at the ribbon machine which happens in spite of selvedge guides, and is partly due to the super-posing of one thin cotton sheet upon another at the ribbon delivery.

A full lap may be 12 to 14 inches diameter, and should be hard and firmly built, with level regular sides or edges.

Greater the resistance of the brake motion, firmer and longer will be the laps.

Draft Rollers.—A sliver lap machine may have either three or four pairs of draft rollers, three being considered sufficient by some men when the ribbon machine follows after and four pairs of the laps go directly to the comber. A ribbon machine always has four pairs of rollers and needs them because it usually has a roller draft of about 6, as against 1·6 for the sliver lap machine or $1\frac{3}{4}$ to 2 over all parts.

Sliver Lap Machine (Fig. 39).

To make laps for ribbon lap machines, or for use on combing machines. The lap is formed by running from 12 to 24 card or drawing-frame slivers (held in ordinary cans behind the machine), through guides and stop-motion spoons, to a drawing head, consisting of three or four rows of top and bottom rollers arranged with a slight draught, which rollers should be set from $\frac{1}{4}$ inch to $\frac{3}{8}$ inch wider than length of staple used. The cotton is then condensed by two pairs of heavy calender rollers, passes to the spool held between two circular discs and driven by a pair of shell rollers, and is formed into laps up to 16 inches diameter; machines of width to suit comber. If ribbon lapper is used the lap from sliver lap should be 2 inches narrower than comber lap.

Automatic Back Stop-motion for each sliver, causing the machine to stop instantly an end breaks.

Full Lap Stop-motion to make laps of uniform length.

With sliver plate or with > table.

Ribbon Lap Machine. To Draw and Double Four Laps into One.[1]

Four laps from sliver lap machine are placed in the creel and drawn through four rows of fluted rollers, whose draught can vary from four to six according to the weight of lap required. The rollers should be set $\frac{1}{8}$ inch to $\frac{3}{8}$ inch wider than length of staple used. This machine draws the fibres into parallel order and makes the laps more uniform and in a better condition for treatment on the comber.

Weight Relieving Motion to prevent the flattening of top roller leathers when the machine is stopped for any length of time.

Curved Brass Plates, highly polished, guide the ribbons evenly over each other on the sliver plate, along which the ribbons are drawn through calender rollers to the lap head to be compressed and formed into a lap up to 16 inches diameter, ready for the combing machine.

Back Stop-motion stops the machine whenever a lap in the creel breaks down or runs out.

One ribbon machine for six combers.

[1] See Fig. 40. Some makers prefer to have six laps in the creel.

Full Lap Stop-motion to make laps of uniform length.

Patent Stop-motion if required, to stop the machine when the front rollers begin to "lick" or lap.

Creel for spare laps.

On some makes of ribbon machines there are usually six back laps for one front or delivered lap.

Lap Machines.

Roller Settings and Drafts.—As regards roller settings at these sliver and ribbon lap machines, the dimensions of the sheet of cotton always demand roller centres to be in excess of cotton fibre length by about $\frac{1}{4}$ inch between front and second pairs from delivery,

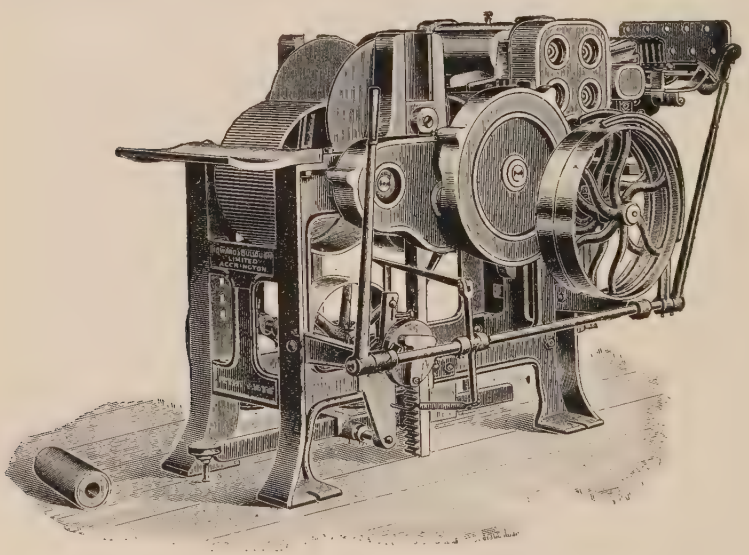


Fig. 39.

and about $\frac{3}{8}$ inch between the centres of other pairs. For example, with rollers $1\frac{1}{2}$ inch diameter and Egyptian cotton $1\frac{1}{2}$ inch long the first distance may be $1\frac{3}{4}$ inch and the other centres $1\frac{7}{8}$ inch apart.

The draft at the sliver lap machine is not intended so much to make a finer lap sheet as to make a level one and to help slightly in making the fibres parallel; more than $2\frac{1}{4}$ or $2\frac{1}{2}$ total draft at the sliver lap machine tends to make lap sheets too soft and inclined to give waste at the next machine. Metallic rollers are often used for the sliver and ribbon lap machines, but their use is a matter of opinion.

(*a*) *Adjustments.*—The spoon levers at the sliver lap machine and the plate levers of the ribbon machine should be balanced so that slivers or lap sheets of normal weight will hold the levers down firmly; but any excess of this effect will prevent the levers from acting promptly and stopping the machine when the cotton fails.

(*b*) *Selvedges.*—The revolving circular lap end plates require to be set to bite firmly against both bobbin edges, and the final selvedge guides for the slivers need to be set very accurately to the exact width of lap, otherwise there will be defective edges to the lap, and these edges ought to be absolutely clean cut. The two vertical racks require to be of same exact height to get both selvedges alike and to make truly cylindrical laps. The brake motion should be kept accurately working and oil kept from it.

(*c*) *Power and Productions.*—About $\frac{1}{2}$ to $\frac{3}{4}$ horse-power should serve for one sliver or ribbon lap machine, but too much brake resistance, calender rollers binding, extra number of ends up, heavily weighted rollers or too deeply set gearing wheels, add to the driving weight of a machine. Weekly productions of these machines may vary considerably according to number of ends fed, thickness of slivers, and of lap sheet. For a week of forty-eight hours an average production under average conditions may be about 2,600 lb., but higher and lower productions obtain in different places.

One sliver lap or one ribbon may serve six combers of the Heilmann type, or four of the Nasmith type, or the work of one comber tenter. On any of these machines a pointer may be connected with the stop rod, so that a foreman may see from a distance whether the machine is working. Not considered necessary in many mills.

Weighting of Calenders.—At the front of the machine just before making the lap thereare often two pairs of calenders, saddled together and lever weighted. Sometimes a double lever weighting arrangement is adopted to increase the pressure conveniently, and thus get firmer lap sheets. Take a case of a 10 lb. weight acting with a leverage of 11 lb. to the fulcrum and the fulcrumage being 1 inch—this operating on a second lever with same lengths and resultant weight going upon one end of the calenders :—

$$\frac{10 \times 11 \times 11}{1 \times 1} = 1{,}210 \text{ lb.}$$

This 1,210 lb. is heavy for one of these machines, and in many cases one lever is sufficient. Indeed, there are cases of dead weights or springs only, giving very much less weight.

In some makes of sliver lap machine four calenders are used as on a scutcher, and these give good compression with light weighting although requiring more space, more driving power, more first cost, and more cleaning.

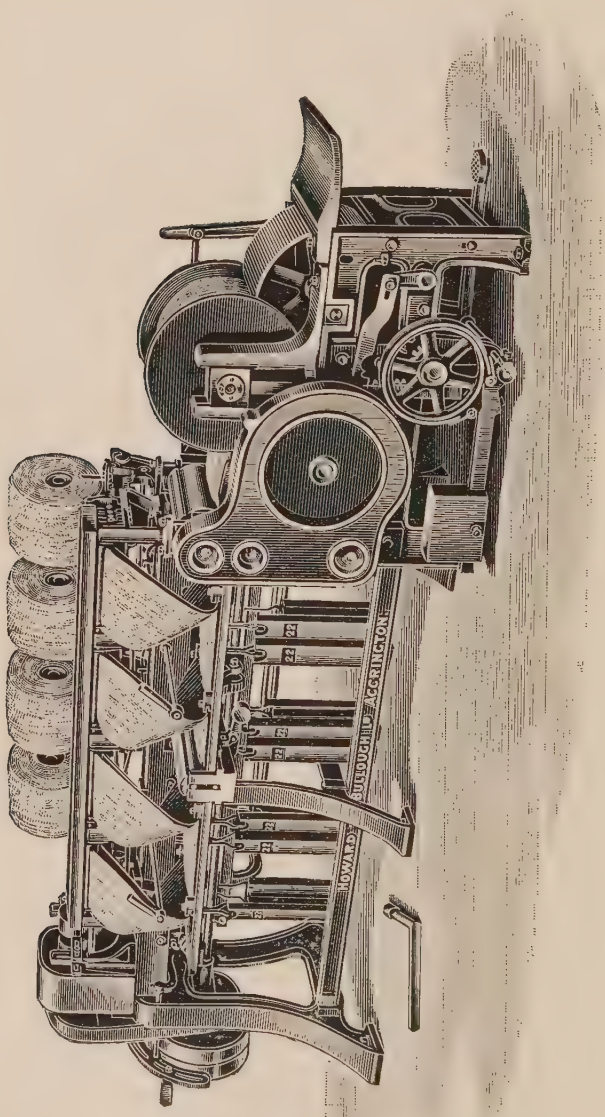


FIG. 40.

Some makers prefer to have six laps in the creel.

Ball Bearings.—Ball bearings have not received very extensive application to cotton machinery at the time of writing, but there are strong indications of their possible increased adoption.

Lap rollers and calender rollers have in some instances been fitted with ball or roller bearings so as to get longer laps and firmer sheets. The present writer having examined these closely and watched them working, considers they will receive greater adoption although there are differences of opinion regarding them in this connection.

First cost is usually an important consideration.

The writer had some draft rollers working with ball bearings as an experiment, in 1921, on mules and frames.

Lap Spindle Ends.—It is always necessary to secure the lap spindle and the circular lap end plates firmly in position, and the usual plan has been to screw the end of the lap spindle by a strong $\frac{5}{16}$-inch thread for the out end plate to screw upon.

Whilst serving fairly well on the whole, these screwed ends have always been liable to develop two particular faults. (1) Sometimes the screwing up sets so firmly that it is very difficult to loosen for doffing, and breakages have thereby resulted. The lap spindle is always withdrawn when doffing full laps. (2) On the other hand, it has sometimes happened that the screws have worn and given a slack fit. Apart from this the unscrewing and rescrewing every doffing takes up a little time which some people think unnecessary.

Consequently, the screwed end in some recent cases has been discarded, and a patent snap fastener applied which fastens and unfastens very readily and yet gives a good working grip (see Fig. 41 (*a*)).

The Brake Motion.—For the most part the brake motion of the sliver and ribbon lap machines has been much on the same principle as for a scutcher, but with shorter levers, smaller weights, and without wheel purchase to increase the brake pressure. The same principle has been adopted of having a semi-circular leather-covered brake operating against the under side of the brake pulley. Good practical men have generally been able to get good firm laps with this ordinary brake motion, but improved forms of brake have been deemed advisable by some people.

In a recent example a steel band encircles all the upper portion of the brake pulley, passes down the sides of pulley, and has its two ends connected with the brake lever (see Fig. 41 (*b*)).

The brake lever is fulcrumed so that the weight pulls down at the brake band instead of the usual upward pressure, and this brake acts against about $\frac{4}{5}$ of the pulley surface.

A fairly long lever is used, and considerable resistance may be applied to the brake pulley.

Accompanying this improved brake, is a contrivance for

automatically sliding the weight nearer to the fulcrum as the lap increases in diameter, so as to diminish the pressure upon the lap.

On the brake pulley shaft is a small wheel which drives a horizontal rack which is coupled to the sliding weight at its other end. The slow turning of the brake pulley draws the special rack along so as to place the weight nearer and nearer to the fulcrum.

Stop-motions.—Stop-motions on the sliver lap machine require to act promptly in order to prevent broken sliver ends from moving too near the delivery of the machine before stopping is effected.

As ion the draw-frame the spoon-lever principle is the funda-

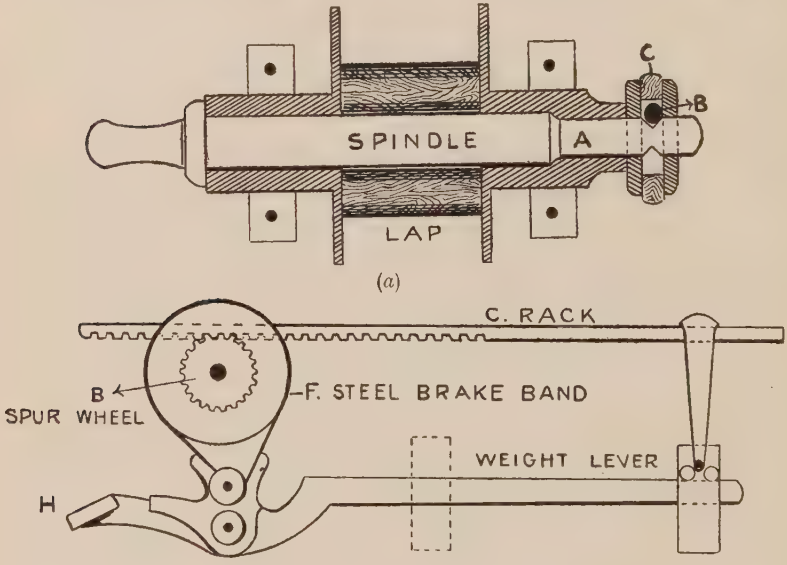


FIG. 41.

mental factor, while the executive part, or the mechanical details, may differ considerably with different makers.

In one recent example the sun and planet, three-bevel wheel combination is utilised as on a yarn wrap reel. The three-bevel wheels are driven quickly round from the gearing, and the final bevel being secured to the long side or wing shafts of the stop-motion, the shafts are in this way revolved beneath the rear ends of the spoon levers on both sides of the triangular sliver table. Failure of any one of eighteen to twenty-four slivers stops the lightly driven wing shaft, so that the central carrier or planet bevel cannot revolve the final one of the three bevels, and immediately runs round

the same bodily as we see the planet wheel in the yarn wrap reel or in the Holdsworth differential motion.

In other words the driven bevel momentarily acts as a fulcrum to the planet bevel so that the first or usual driving side bevel for a moment operates as the final or driven bevel and takes round with a can whose full part now moves a suitable lever side-ways and by proper connecting rods promptly moves the belt upon the loose pulley.

Lap Calender.—In some lap machines a revolving calender is allowed to definitely rest on top of the lap as it is formed, and this method undoubtedly helps in giving good laps. Special driving for this top calender is used so as to maintain its surface speed much the same as that of the lap as the latter increases in diameter, yet without putting too much friction on the lap.

Doffing Full Laps.—Release brake motion by foot treadle; lift the vertical racks somewhat higher to release the lap spindle; unscrew the circular end flanges or otherwise release them, and draw out the lap spindle; take out the full lap and replace a fresh empty tube; replace the lap spindle and properly lock it and the circular lap end plates; conduct the lap end upon the tube; re-apply the brake motion and start the frame.

For full laps probably the best known and simplest automatic stop-motion is operated from one of the vertical racks. The rack carries an adjustable bracket which releases the stop rod lever when the rack has been sufficiently lifted by the increasing diameter of lap.

When very exact lengths of lap are required it is probably best to apply a measuring motion operated from the bottom calender roller on the principle applied to some other machines.

Curved Front Plates of Ribbon Machines.—The ribbons of cotton emerge from the draft rollers in their most delicate condition, and are really in a good state for taking the peculiar half turn at right angles around the curved front plates. Electro-plating or nickel-plating, or covering with brass of these plates, helps the passage of the cotton. Cleanliness of these plates is fundamental.

Weights of Lap.—These depend upon the kind of work, the productions aimed at, the use or otherwise of the ribbon machine, the width of lap, the length of feed at the comber, and whether the lap is for use at the Heilmann, Nasmith, Whitin, or other make of comber. For the standard 10½-inch width of lap about 12 to 15 dwts. per yard for the Heilmann, and 18 to 24 dwts. for the Nasmith are common. For the Nasmith especially there are great variations in lap weights to suit different conditions and ideas.

Gauges.—There are various special gauges and tools used on the combers for one purpose or another.

The gauges in common use for the Nasmith differ from those for the Heilmann, although mostly of the same fundamental character.

Very wide thin-lipped pliers are in use for helping to straighten bent needles.

Similarly small brushes are made up into the shape of pincers or scissors to facilitate cleaning of the top combs.

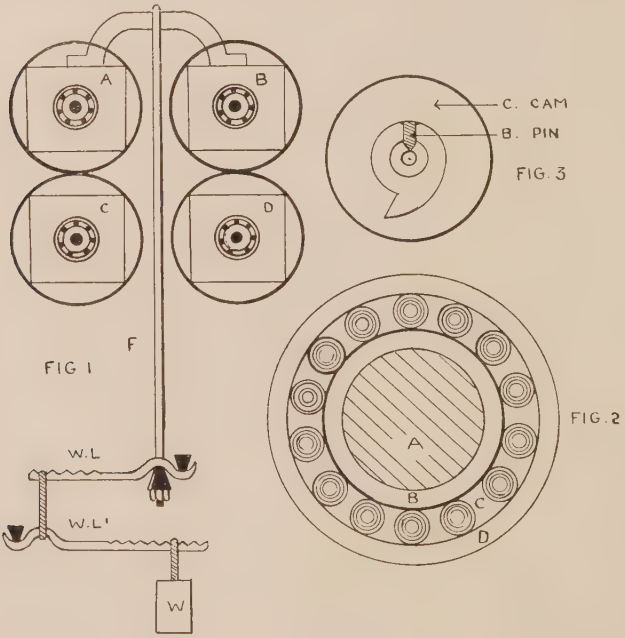


FIG. 42.

Three recent ideas are indicated in the general figure.

(*a*) At Fig. 1 is shown a double leverage, WL, for weighting the calenders, AB.

(*b*) At Fig. 2 a ball bearing for the lap spindle, A.

(*c*) At Fig. 3 a snap fastener pin, B, and a cam, C, for locking the spindle firmly in working position, yet permitting easy and safe release.

The Heilmann Cotton Comber.[1]

The Heilmann comber first succeeded in attracting the direct practical interest of British textile men at the great London Exhibition of 1851.

Heilmann's French patent, however, was dated in 1845, and accompanying this he gave a good description of the objects aimed at in regard to combing long staple cotton, and the extraction of

[1] References to the new double and twin cotton combers are given in the Addendum.

fibres below a certain length, as well as fine impurities. Syndicates of machinists and spinners purchased the British rights at rather high prices, and Messrs. Hetheringtons became sole makers of Heilmann's cotton comber for the duration of the patent rights.

From Card to Comber.

For many years the standard practice was to pass card slivers through one head of draw-frame, then the Derby doubler, and then behind the comber.

About 1890 the ribbon lap machine began to receive attention, and the Nasmith comber and use of heavy laps from about 1904 forward give a fillip to the adoption of the ribbon machine so that the favourite and most standard method has become as follows:—

Card slivers to sliver lap machine to be made into laps mostly about 9 inches wide.

Six of these laps doubled together at the ribbon lapper and made into laps 10½ inches wide for the comber.

During recent years various rearrangements and process combinations have been tested between the card and the comber.

The simplest of all is to convert card slivers directly into narrow lap for the comber without using either draw-frame or ribbon machine. This imposes too much work on the needles and central organs of the comber and increases the waste percentage at comber without corresponding benefit in the yarn. It is not recommended at all.

The other extreme is to use both the extra draw-frame, the sliver lap and also the ribbon lapper before the comber, and this puts the individual cotton fibres into very good condition for needle, nipper, and detaching treatment at the comber.

A reduced percentage of waste may be expected behind the comber from this excessive preliminary treatment, but the thin sheets of cotton are apt to become very soft, inclined to lap-licking, and generally somewhat troublesome to work. The tremendous increase in price per lb. of best cottons occurring in 1920 caused experiments to be made even with two draw-frame passages, sliver lap and ribbon lap and single combing.

Timings and Settings for Sea Islands Cotton.

The timing and setting of a combing machine are of the utmost importance in any case, and are affected somewhat by the following considerations: The amount of waste to be taken out, the length of staple and the weight of lap operated upon. In setting, certain gauges of special construction have to be used, and very great assistance is rendered in timing and setting by the index wheel fixed on the cylinder shaft at the end of the machine. This wheel contains eighty teeth as the standard, and is divided and marked out

in twenty portions of four teeth each, with a special pointer to show the positions accurately. We refer now to the Heilmann comber. This method of division provides that one tooth is a quarter of a mark, two teeth a half, and, of course, three teeth three-quarters of a mark, without any necessity for these subdivisions being marked on the face of the index wheel. The timing and setting of a comber bear a strong analogy to the timing and setting of a loom or mule, in the importance of their effect upon the correct working of the machine; but the difficulty of adjustment on a comber is greatly minimised as compared with the other machines by the provision of this index wheel. Loom overlookers would doubtless more readily acquire facility in making correct adjustments if they had an index wheel marked out in this fashion, and instructions were given to them to get the shedding to commence at $4\frac{1}{2}$ and the picking at 6, and the beating up to $10\frac{1}{4}$, etc. Similarly mule overlookers would not be liable to get far wrong if they had to set the backing-off friction to engage at $7\frac{1}{2}$, the fallers to lock at $8\frac{3}{4}$, etc. We put it this way because this is largely what is the case with the comber by the provision of the index wheel just explained. The feed rollers for long Sea Islands might be set $2\frac{1}{16}$ inch from long steel detaching roller, the latter being an important setting point, although in this respect being probably second to the cylinder. With the index wheel at about 5 we might have $1\frac{1}{8}$ inch gauge between front edge of fluted segment on the cylinder and long steel detaching roller, and we might have a 22's gauge between flutes of the same fluted segment and the flutes of the long steel detaching roller. The nippers ought to have a sheet of writing paper to bite equally and firmly between them, and there may be a $1\frac{7}{16}$ inch gauge used between front edge of cushion plate and long steel detaching roller for long Sea Islands cotton, and the nipper knife might be set with about a 21's gauge between it and the needles of the cylinder. As regards the leather detaching rollers, we might set them to have a piece of writing paper between the flats of their brass ends and the lifters, when the latter are in their lowest position, and the leather rollers are resting on the fluted segment of the cylinder. The top combs may be set to have a 19's gauge between them and the cylinder fluted segment, and to about 14's angle. As regards timing, the feed rollers might be set to move at about 5, the detaching roller about 6, the top comb to be down $5\frac{1}{2}$, the nippers to close about $9\frac{1}{4}$, and the clutch wheel to be in gear at about $\frac{3}{4}$, all these, of course, being approximate timings. For Egyptian cotton the above settings would also largely hold good, the chief exceptions being that the distance between flutes of detaching and feed rollers would be reduced to $1\frac{13}{16}$ inch, and the distance between flutes of detaching roller and front edge of cushion plate would be reduced to $1\frac{3}{16}$ inch.

Long Egyptian need not differ much from short Sea Islands in timings and settings, but distinct differences are required between long Sea Islands and moderate Egyptian.

Curled or Cloudy Webs.

Curliness of the fine web delivered by a comber head is of very frequent occurrence, and is sometimes difficult to remedy.

A very common cause is not having the short top fluted piecing roller parallel with the other two detaching rollers. This roller can be very readily disturbed from a parallel condition owing to the method of sustaining it. The intermittent action of the machine and carelessness of tenters may lead to its disarrangement. Very dry weather sometimes leads to the evils specified, and recourse in such cases may be had to the degging can.

Curling is very frequently caused by defects in connection with the leather-covered detaching rollers, such as being short of lubrication, badly covered with leather, and not being properly set and timed. The remedies in such cases are obvious.

Cloudiness of the fine fleece may be caused by unlevel setting or covering of the nippers. If the nippers do not hold the cotton firmly all across, the fibres are liable to be pulled through in tufts, and good fibre pulled into waste. Dirty cylinders and flocking should be guarded against to prevent cloudiness of the web.

Faults in Combing.

There are many finely adjusted parts on a comber, and a slight disturbance of these parts will easily affect the work detrimentally. The intermittent action of the principal operating parts of the machine and the high speeds of the parts are contributing factors in such disturbance. In a general way it may be said that the necessity for comparatively frequent re-setting of a comber is one of its faults, and unless it be properly attended to there may be an excessive amount of waste extracted without corresponding benefit in the combed sliver. "Curling" of the fine fleece in the collecting tins is one common defect, and very frequently may be attributed to some defect in the detaching rollers, such as the leather rollers requiring to be re-covered or re-varnished, or skimmed up, or the leather rollers binding in their loose end bushes. If the detaching rollers are not parallel to each other, or if the atmosphere is very dry, the slivers are liable to come out curly. Want of lustre in the cotton webs is sometimes due to high productions or imperfect action of needles in the fibres. Unlevel setting or covering of the nippers may give cloudy webs or excessive waste. "Flocks" and bad ends may be caused by damaged cylinder needles sticking to the fibres, while wrong setting of rotating brushes and doffers is often responsible for reducing the quality of the waste. It goes

without saying that correct timing and setting of nippers, top comb, detaching rollers, and feed rollers are essential for proper work, and it is no less important that the needles of the cylinder and top comb be kept in good condition.

Gauges for Heilmann Comber (general Figs. 43, 44).

1. A fundamental setting is to have the index at 5 and have all the six or eight separate cylinders adjusted in exact line, placing the $1\frac{1}{8}$-inch gauge as at A, Fig. 1 (plate), between front edge of fluted segment and long steel detaching roller, and having the steel roller at 21's, 22's or 23's gauge from the cylinder.

2. With the nippers fully open and the cushion plate in its most forward position the gauge B, Fig. 1, should fit between the steel roller and the front edge of the bottom nipper or cushion plate. (For these various gauges see general Fig. 43.)

3. At Fig. 3 (plate) is shown a wire gauge, and such gauges as that in figure receive their thickness number, 16 to 23, from fitting accurately in the corresponding aperture of the wire gauge. Steel detaching rollers, nippers, and top combs, are tested for distance from cylinder by these trowel or feeler gauges.

4. Fig. 2 (plate) shows a stepped or ladder gauge. This gauge is used in setting the nippers for distance from cylinder and for amount of opening or rise.

This stepped gauge is placed between the stop-screw or horizontal setting screw of the bottom nipper, and the nipper stand. With ladder gauge in this position, we may hold the correct trowel gauge between nipper and cylinder needles and raise or lower the nippers as required by the vertical nipper screws.

5 The $1\frac{3}{16}$-inch gauge (about $\frac{1}{8}$ inch thickness for all gauges yet refer.red to except the ladder gauge) is used to set all the bottom feed rollers at that exact distance from the bottom detaching roller for average Egyptian cotton. This gauge may be $2\frac{1}{16}$ inch for long Sea Islands cotton.

6. Fig. 6 indicates a handy gauge for setting one shaft parallel to desired distance from another shaft. For example, in setting the shaft of the revolving brushes correctly to cylinder shaft.

7. A cradle gauge often used to facilitate the adjustment and accuracy of amount of angle in top combs. An angle gauge may be used to get one top comb of exact angle, the cradle gauge then adjusted to this correct comb, and the other combs then more quickly adjusted by the cradle gauge than by using the angle gauge all over.

8. Fig. 9 (plate) indicates the several adjustment points of the top comb. The cradle gauge H is shown in position on the detaching roller DR, with the set-screw *a* ready to adjust the angle of top comb TC which has been sufficiently loosened at the angle bolts S.1.

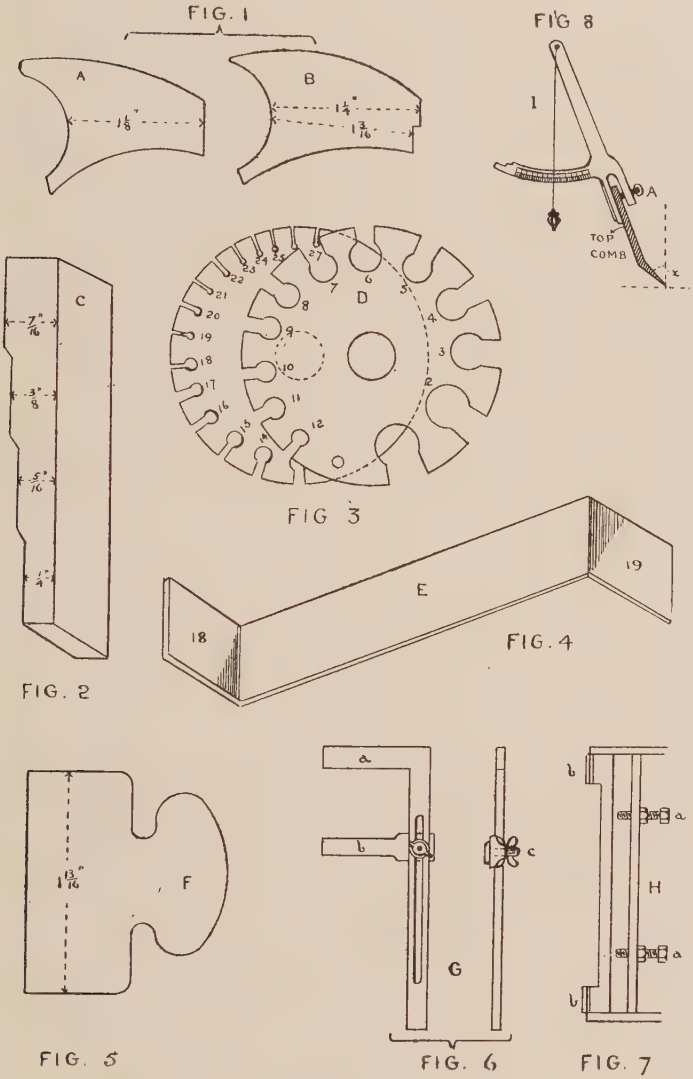


FIG. 43.

At S2 is the vertical adjustment screw for top comb, resting upon the framing B. At S3 is the small back set-screw for deciding how much the top comb shall be lifted clear of the cylinder

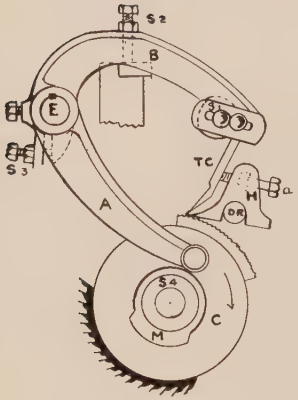


FIG. 9

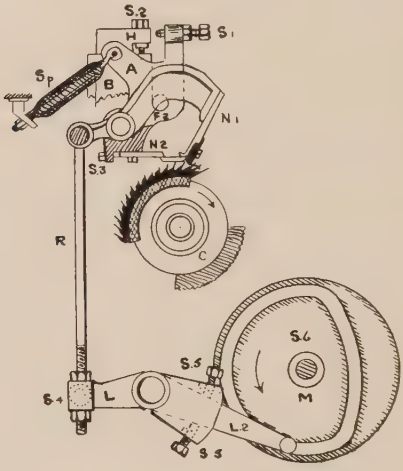


FIG. 11

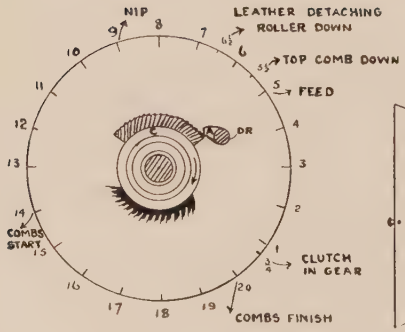


FIG. 10

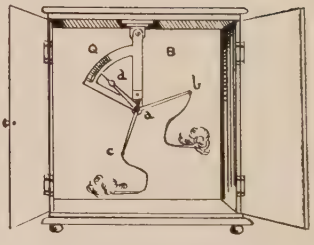


FIG. 12

Fig. 44.

needles when the latter are on top. At S4 is the end cam M on cylinder shaft for lifting the top combs, and there is a set-screw

for quickly altering the time of top comb lifting in relation to cylinder needles reaching the top position.

9. Referring now to Fig. 10, the Heilmann index wheel of eighty teeth contains twenty marked divisions of four teeth each. At A is shown the $1\frac{1}{8}$-inch gauge in position for lining up the fluted segments of cylinder from steel roller DR. Approximate timings are marked on the index wheel.

10. Fig. 11 is a diagram prepared to help in discussing the adjustments for the nippers, which require considerable attention in a thorough re-setting and overhauling.

At S6 we have the cam M on the cam shaft, there being usually one cam near each end of the cam shaft. It is easy to loosen a sidebolt and move the cam either way round within limits, in order to vary the time of nipping in relation to the marks of the index wheel, or the time of cylinder needles acting on the cotton. (For these various settings and gauges see general Fig. 44.)

At S5 a number of nippers may be raised or lowered together in relation to the cylinder.

At S4 are convenient nuts for adjusting how near each nipper shall approach the cylinder needles.

At S3 small set-screws for getting upper and lower nippers quite parallel.

At S2 are set-screws for raising or lowering the nippers bodily, in relation to cylinders.

S1 is a set-screw for determining how soon the lower nipper must be stopped, while the upper nipper continues to lift; in this way is decided how widely the nippers shall open for detaching. Most of the adjustment screws run in pairs, right and left-hand for each head.

11. Fig. 12 (plate) indicates a percentage balance as used by some firms, but not by all spinners, for quickly ascertaining the percentage of comber waste. The comber is stopped, the good sliver and also the waste nipped off clean at delivery point. Comber operated from thirty to forty nips, good sliver and waste carefully taken off. Waste in one pan, good sliver in the other, the scale at once denotes the waste per cent. Many firms simply use ordinary balance and make simple calculations for waste percentage.

Weight Relieving Motion for Combers and Lap Machines.

In sliver lap machines and ribbon lap machines it has been customary to relieve the weight from the top draft rollers in cases of prolonged stoppage, just as in the case of all other machines in a spinning mill. Such un-weighting prevents flat places or flutes forming in the leathers of the top rollers.

In a common arrangement for sliver and ribbon lap machines

the weights are affected by lifting bars suspended by links from eccentric shafts, and the mere turning of a handle lifts the weights from the top rollers, if the apparatus acts as intended. Sometimes, however, weights tend to tilt on one side instead of lifting vertically and accurately, and this tilting may result in weights becoming unhooked on one side—always a trouble in replacing.

Detailed improvements have been effected so as to keep the weights, hooks, and wires in a more accurate vertical line, and at the same time to turn the eccentrics slowly and smoothly round by means of a worm and worm-wheel arrangement.

Double Top Combs.

These are in use in a few cases only. With two rows of needles in a top comb the cotton may come first between a row with thirty needles per inch and then one with sixty per inch.

Naturally a more effective cleaning and combing of the tails of the cotton fibres is expected from using two rows of needles instead of only one, but double top combs possess serious disadvantages which prevent their more extensive adoption :—

1. More liable to come in contact with nippers or detaching rollers.
2. Dirt and fibre are likely to get fast between the needles and sometimes fall back again into the good cotton.
3. Top combs more difficult to clean.
4. Top combs more costly.
5. Top comb needles more difficult to put straight when bent.

Anderton Nipper.

At 3 (Fig. 45) is indicated the base idea of what is termed the Anderton nipper for the Heilmann comber. A cushion of good soft roller leather is secured to the base of the upper nipper as at A compared with the metal nipper base as at B. This special cushion gives a firm nip to the cotton against the lower nipper, and permits very close setting to the cylinder needles with a minimum of danger to the needles. If contact accidentally takes place with the needles, the leather will yield. Many of these special nippers have been applied, but it is for any individual firm to say whether they think the extra cost is warranted.

Another recent improvement in Heilmann combers consists in rearranging the bearings of the leather-covered detaching rollers so that the weight hook comes inside the bearing instead of outside. The weight hooks of the leather-covered detaching rollers are thus distinctly closed in, with benefit to the detaching action.

Extraction of Short Fibre.

At 4 is a lecture diagram to illustrate how a comber may extract short fibre as waste and yet leave the long fibre in the sliver.

Assume cotton fibres $1\frac{3}{8}$ to $1\frac{1}{2}$ inch long, such fibres will be gripped by the leather roller D before leaving the cushion plate C. From nip of C to nip of D is put at $\frac{7}{8}$ inch. Fibres of shorter length than $\frac{7}{8}$ inch are likely at some time to be free from both nipper and detacher, and in such a loose condition that the top comb detains them, and the cylinder needles remove them to the back of the machine as waste. The several figs. referred to on pages 198-9 are assembled under the general Fig. 45.

Cushion Plate.

At 5 two kinds of cushion plate long in use for the Heilmann comber.

Method at AB is the more recent one, having the cushion of leather in the upper nipper because of greater facility in renewing or alteration.

The older method A′B′ has the cushion on the lower nipper, hence the term cushion plate.

The Nasmith comber appears to give a good firm grip on the cotton fibres, without any cushion whatever on either nipper, and is considered to do this without injury to cotton fibre because of slow, mild, shutting of nippers.

Positions of Central Organs.

Fig. 1 shows positions of central organs of Heilmann for cylinder combing.

Nippers closed, cylinder needles on top, leather detaching roller away from cylinder, top comb lifted, feeding and detaching momentarily suspended.

Fig. 2 (plate) shows positions of central organs for detaching.

Feed rollers A, A projecting the cotton forward, nippers B, C open, top comb D down, leather roller G momentarily touching fluted or detaching segment H of cylinder; cotton turned back from detaching rollers E, F, G, ready for fresh piecing.

In the Nasmith comber, there are no flutes in the cylinder detaching segment, and no detaching roller ever touches any part of cylinder.

Duplex Comber.[1]

About 1895 there were great hopes of increased production from the duplex comber with two sets of cylinder needles each thirteen rows. Abrupt action of parts has restricted its adoption.

Fig. 6 (plate) shows a section of a cylinder of the Duplex comber. One revolution of cylinder gives two complete combing and detaching operations, because there are two fluted segments AA′, four making up pieces CC′, C″, C ″, two needle segments BB′, 120 nips per minute from 60 r.p.m. of cylinder.

[1] The most recent attempts to obtain increased comber production are described in the Addendum.

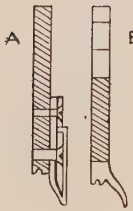


FIG. 3

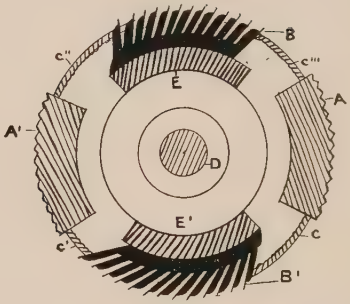


FIG. 6

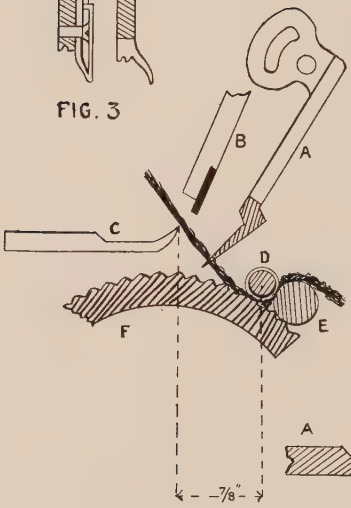


FIG. 4

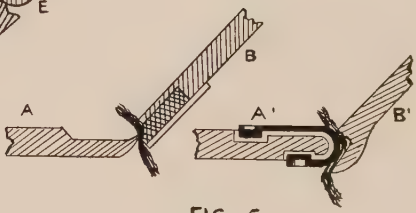


FIG. 5

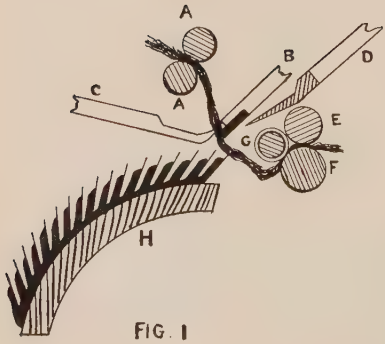


FIG. 1

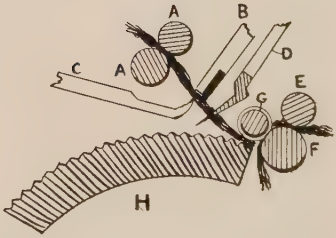


FIG 2

Fig. 45.

The Whitin High Speed Comber.

This comber was introduced from America about 1910 by Messrs. Howard & Bullough. It is a productive machine on the Heilmann principle, but containing a number of alterations in the central organs, designed to give increased production from increased speeds rather than very heavy lap sheets.

Examining the central organs progressively, the feed rollers in driving, weighting, and construction differ little from the well-known Heilmann constructions, containing a 5-notch star wheel for driving, an adjustable feed-peg, and spiral spring weighting.

By invitation, the present writer examined very fully the first machine of this type built in England. More recently, this firm has begun to make the fine cotton comber shown elsewhere in this chapter.

The Nippers.

In regard to the nippers we are at once confronted with a most important and radical difference in operation as compared with the typical and standard Heilmann. This difference is really one of actual operation of nippers rather than of construction. It is well known that the orthodox action in the Heilmann comber in bringing the nippers into action is to depress the nipper knife or upper nipper by means of the cams on the cam shaft, and the vertical connecting and adjusting rods, until the upper nipper meets and engages the lower nipper or cushion plate, and then the two move together for possibly another $\frac{3}{8}$ inch or so, the force of the top nipper overcoming the resistance of the spiral springs, which always try to draw the bottom nipper towards its highest position as determined by the horizontal setting screws. The important alteration in the Whitin comber is the elimination of the swinging or rocking movement of the cushion plate or bottom nipper. It occurred to the writer that possibly damage might result through the top nipper charging the bottom one too severely, but apparently this could only take place through some hard substance passing in with the lap, and even then the cushion plate could not be forced into the cylinder needles, although a slight breakage might occur. This nipper frame is adjustably fixed stationary in combing position, and this correspondingly reduces the amount of throw necessary for opening the nippers, in itself distinctly tending towards the reduction of vibration in the comber. Moreover, since the swing frame usually comes immediately below the feed rollers, the fixing and holding of this frame or cushion plate in its lowest or combing position, enables the feed rollers to be also dropped in position proportionately. The practical benefit derivable from this is the possibility of combing a shorter staple of cotton, since the

"bite" of the feed rollers is brought closer to the "bite" of the nippers. This is one of the very special features of the Whitin-Bullough comber, and deserves the consideration of our readers. With regard to the shapes of the nippers, the bottom nipper or cushion plate is brought to a fine point, upon which the upper knife or top nipper is dropped, a cushion of leather being fitted into the top nipper so as to grip the delicate cotton fibres without injury. The method of adjusting the nippers is much the same as for the ordinary Heilmann, the top nipper having usually an angle of about 35° from the vertical, and the front edge of the cushion plate being set to about $1\frac{7}{16}$ inch from the long steel detaching roller. The top nipper is made to have two oscillations for one revolution of the cam shaft.[1]

The Cylinder.

The cotton having been fed through the open nippers, and then the nippers having closed upon the cotton fibres, the heads of the fibres, or their front extremities, are combed by the cylinder needles, the intermittent feed or projection of about $\frac{1}{4}$-inch length of fibre per nip ensuring that the tips of the fibres shall be acted upon by the cylinder two or three times before detaching, this varying with the length of fibre, the distance of long roller from feed, and the length of feed per nip. There are some important differences in the construction of the cylinder. In the first place, it has been found possible, with the rearrangements to apply twenty rows of needles to the half lap or needle segment, and the adoption of this increased needleage naturally increases the combing capacity. The standard number of rows of needles adopted for very many years past in the ordinary Heilmann single nip comber has been seventeen rows, a practice which has also been followed in the Nasmith comber.

Small Clearers.

As an interesting detail it may be here stated that on the outer cylinder, over an arc of possibly 3 inches, bristles are fixed which apparently serve a most useful purpose in automatically and continuously keeping the ends of the detaching rollers free from accumulations of fibre. These small brushes or cleaners are themselves cleaned by the revolving waste brush. The half laps and the detaching segments are screwed down firmly in the usual manner to the cylinder stocks, and there are the two making-up pieces between the needle and detaching segments in much the usual manner. The individual cylinders for each head are secured as

[1] "Cotton Combers," by the same author, first issued 1904, deals very fully with the Heilmann comber.

usual to have all the front edges of the segments at $1\frac{1}{8}$ inch from long steel detacher when the pointer of the index is opposite the number 5.

As prepared by the makers, there are diagrams to illustrate the actions and positions of the central organs.

Details of Whitin Comber.—A standard Whitin system comber of this make contains eight heads, to take laps 12 inches wide and up to 16 inches diameter, needle segments with twenty rows of needles.

Draw box with four lines of rollers so geared that a single change alters the draft in the draw box and the speed of the coiler at the same time.

Electric stop-motion acting promptly when a sliver fails or breaks, or a roller lap is formed, or the sliver can becomes sufficiently full. A vertical rod contains a pointer signal which indicates to persons at a distance whether the comber is working or not.

An improved waste packer which greatly increases the holding capacity of the back waste boxes.

The circular revolving brushes driven by a variable gearing motion giving three speeds of brush shaft, so that revolutions may be increased as brushes wear shorter; a longitudinal traverse motion may also be applied to the brush cylinder to increase the cleaning efficiency.

A weight-relieving motion may be applied to the draw box rollers or the top detaching rollers, and a device may be applied which keeps the machine stopped so long as detaching roller weights are raised away. By dispensing with the movement of the cushion plate and eliminating the cams and connections for lifting the detaching roller the mechanism is simplified; there are fewer reciprocating parts and vibration is thereby reduced to a minimum.

The detaching and nipper cams repeat, reducing the speed of cam shaft to half that of combing cylinder. Nips per minute up to 130 according to quality of combing.

Comber Calculation.

How many lb. will a 6-head comber produce per $56\frac{1}{2}$ hours? Lap 9 dwts. per yard, 80 nips per minute, machine working 50 hours, $\frac{1}{4}$ inch delivered per nip per head, waste 20 per cent.

This calculation is typical and peculiar to the comber, and it requires to be particularly noted that we take $\frac{1}{4}$ inch per nip as a basis, with 80 times $\frac{1}{4}$ inch per minute per head. Also in allowing for the waste per cent. we reduce the output of good sliver by the expression $\frac{80}{100}$ and not $\frac{100}{120}$ which would be quite a different thing. Every yard weighs 216 grains, so we reduce to yards.

$$\frac{\begin{matrix}\text{Nips per min.} & \text{Mins. per hour.} & \text{Hours.} & \text{Heads.} & \text{yd.} & \text{Grains per Loss.}\\ 1 & \times\ 80 & \times\ 60 & \times\ 50 & \times\ 6 & \times\ 216 \end{matrix} \times 80}{\begin{matrix}4 & \times\ 12 & \times\ 3 & \times\ 7000\\ \text{inches.} & & \text{feet.} & \text{grains.}\end{matrix} \qquad 100\ \text{loss.}}$$

$$= \frac{24 \times 9 \times 8}{7} = 246{\cdot}85 \text{ lb.} \quad \text{Answer.}$$

Re-setting of Heilmann Comber (see Gauge illustrations, Figs. 43-44).

A comber may be re-set and thoroughly overhauled once in twelve months, but it is done more or less frequently by different firms. The procedure does not differ very much with different makes of comber although details of construction differ somewhat, especially in the driving of the detaching rollers, in some combers being obtained from a clutch box and quadrant, and in others by an internal wheel and large notch wheel, and some combers have the cushion in top nippers, while others have it in bottom nipper.

Stripping the Comber.—The taking-down of the comber for re-setting differs slightly because of such detailed constructions as above referred to.

Strip the comber of almost everything excepting beams, stands, lifter shafts, cam shaft, cylinder shaft, nipper lever shaft. This stripping is the first job, and leaves everything easy to get at for re-setting, alterations, repairs, renewals, and thorough cleaning and overhauling.

General Examination.—All half laps to have needles made good, all worn bearings to be closed in or renewed, leather rollers probably re-covered or at least re-varnished and possibly skimmed up. Cards and combers require re-setting and thorough overhauling more often than any other machines in the spinning mill, and the work should be done with real skill and care.

Fluted rollers to be cleaned and scoured, such as steel detaching rollers, bottom draw box rollers, top and bottom feed rollers; also fluted cylinder segments. All smooth metal parts touched by cotton to be well polished.

The spirit level may be used to various parts to see if comber parts are quite level.

Sometimes advantage is taken of scouring and re-setting to apply recent detailed improvements. A good comber re-setter needs the ability to properly handle a file.

Cylinder Needles.—A fundamental and primary duty in overhauling is to get the cylinder needles into good condition. Broad lipped pliers may be used to straighten bent needles. Should any needle segment have three or four needles missing or broken in

three or four rows together, such half laps should be changed for good ones, or quickly repaired at the machine shops. There are firms which do little else but repair half laps or needle or needle and specialise in this work. The needles are soldered on to brass strips which are set-screwed to cast-iron shells. The standard for both Heilmann and Nasmith has been to have seventeen rows of cylinder needles, but the duplex half lap had only thirteen rows, and some modern combers have twenty or twenty-two rows of needles in each half lap.

Chief Covers.—These tins should be well polished, replaced, and carefully set so that each tin shall be clear of the cylinder at all points, but as near to its work as convenient without rubbing. Nuts and bolts secure the back tins or covers to the main beam of comber. These covers act as guards for cylinders and brushes, and prevent dust or fibre from flying about. The Roth aspirator, when applied, is an excellent dust remover.

Waste Brushes.—The re-building of the comber is a gradual operation, performed as the re-setting, renewals, and repairs are effected.

The revolving circular waste brushes may now be re-applied. Sometimes new brushes are applied, and these should first be loose on the long brush shaft, and each one should be apportioned out and set as accurately as possible to be in true line with its own cylinder needles. The approximate arrangement of the brushes may first be done with the long brush shaft resting on floor blocks behind the comber and all got ready for lifting in position. The brush shaft itself must be set level—possibly with spirit level—and parallel with cylinder shaft by the aid of a measurement or distance gauge. Each brush must be set level with each end of its own set of needles. Headless set-screw fastening of brushes to shaft may be employed.

Steel Detaching Roller.—This roller is a base for other adjustments, along with the cylinder, and requires early attention. Replace this long steel roller, put the caps on the bearings, take care to have all the bearings free but not with too much play. It may be advisable to close certain bearings in. Be careful no back tin rubs on the long steel detaching roller.

Segment Lining-up.—With index at 5, use the $1\frac{1}{8}$-inch gauge between long steel roller and front edge of each fluted cylinder segment in turn, in order to get all these segments in exact line and at the right moment. If this is correctly done, other portions of cylinder will come round in line at the proper moment.

Long Feed Roller.—Replace the long steel feed roller—usually in one length—set it by $1\frac{13}{16}$-inch gauge parallel to and properly distant from the long steel detaching roller. Afterwards the long feed roller may be again temporarily removed; partly to allow of

the nipper frames being put in—especially with cushions in bottom nippers.

Nippers.—Re-apply the nipper frames and hold up the nipper arms while the long feed roller is again put in. Put in the cushion plates and fasten by set-screws to the nipper frames, without screwing up tightly, until after the cushion plates have been accurately set to the nipper knives or top nippers, which may now be put in again if not yet done.

Set cushion plate as close as possible to tip of nipper knife, without severe action by small back screws, using writing paper or equivalent between nippers to get a firm and equal bite across width of paper and nipper. Now fasten small set-screws.

The cushion plate may now be set with the $1\frac{1}{4}$ inch gauge parallel to the long steel roller. For this purpose slacken the lock nuts in the vertical stop-screw of nippers, and utilise these screws in adjustment just specified.

Should the nipper stands require adjustment, it may be done by loosening the bolts and knocking the stands slightly up or down as required.

Nipper Knife and first Row of Needles.—When all cushion plates have been set parallel to the long steel detaching roller, the cylinder shaft may be turned round until first or second row of needles comes directly under the nipper knife. Place the ladder gauge of desired thickness between the stop-screw of nippers and framing taking the right-hand screw. This pushes nippers down to cylinder.

By proper screws the nipper knife is set perhaps 18's or 19's trowel gauge from cylinder needles. In making this or other adjustments each separate head will require treatment in turn. Adjustment of nippers nearer to cylinder may have disturbed setting of cushion plate to long steel detaching roller, and this setting should be checked. In some cases nippers may require altering backwards and forwards, or up and down, owing to one adjustment affecting another one.

The nippers must finally be correctly adjusted to the long steel roller on the one hand, and the cylinder on the other hand.

Vertical Connecting Rods.—Following above adjustments the nipper springs and vertical nipper connecting rods may be coupled up, the springs being first put under a moderate tension. Turn the cylinder needles out of the way of nippers, and turn the cam shaft until the full part of nipper cam depresses the nippers.

The lock nuts of the vertical nipper rods are manipulated until the proper step of ladder gauge will fit between stop-screw and nipper frame.

All the rods—two for each head—require individual attention. Before ringing up bolts and lock nuts belonging to nippers, turn

comber until nippers are in lowest position and check with the 18's or 19's trowel gauge.

Top Comb.—Turn cylinder shaft round until nippers are open, index pointing to 7 and middle of fluted segment beneath the top combs which may now be put in. Top comb settings are explained in the gauges section and may now be attended to.

Leather Detaching Rollers.—Place the index at about 8 so as to bring the centre of fluted segment under the leather rollers. The leather rollers ends being well cleaned, the rollers may be properly hooked and weighted into position.

Revolve the cam shaft until each cam bowl rests in thinnest or lowest part of its cam groove, at which time the lifters should be quite clear from the leather roller ends, and each leather roller should rest on its fluted cylinder segment. Slips of writing paper or an equivalent gauge may be used to just fit or just slightly bite between roller end and lifter top. Each lifter top carries a small adjustable bracket to help this setting.

All detaching rollers, feed rollers, and other parts to be quite parallel as this parallelism of central organs is fundamental to correct action on the cotton. Feed roller arms carry proper means for adjustment.

Lap Plates.—Lap plates and wood lap rollers need replacing and possibly some little adjustment. Back end of each lap plate set a little below wooden lap rollers and leading end of lap plate set level with upper edge of bottom feed roller. Most lap plates are fitted with small brushes to help in keeping the feed rollers clean, and in restricting feed roller laps. Feed roller laps do happen sometimes, and if allowed to become large, there is danger of the bottom nipper being forced into the cylinder needles, on the Heilmann comber, but not on the Nasmith comber.

Draw Box.—Cleaning, oiling, re-covering of spoiled top rollers (unless metallic rollers are used), proper setting of rollers parallel and distance apart, form a part of the work attended to now, or any other time convenient. Centre to centre of rollers may exceed length of fibre by $\frac{1}{4}$ inch or $\frac{3}{8}$ inch. Draw-frame practice is applicable to the draw boxes in most details.

While at the draw box the coiler motion may also receive all attention necessary in regard to perfect cleanliness, noting if the sliver has been correctly coiled in the can.

About twenty coils of sliver for one revolution of can is considered good working, and each should extend from just beyond the centre of can to just reach the can edge. Can bottom $1\frac{1}{4}$ inch out of centre with coiler top.

Doffers.—If not previously attended to, the doffers may now be re-applied, noting that all are firmly keyed on doffer shaft, set as near as possible to cylindrical brushes without touching.

If doffers are set too closely to brushes the waste will come out in a torn and ragged sheet, while if too far away the waste will be cloudy and neppy. Apply the doffer comb and set near enough to strip the doffer effectively.

Follow up with the brush covers, which should be set as near as possible to cylinder waste brushes and doffers, without touching.

Timing.—All parts being re-geared and connected, the next thing is to time the comber, one method being as follows:—

Turn the cylinder shaft round until the index points to 6. Turn cam shaft round until long steel detaching roller begins to deliver or turn forward, and then put the cam shaft wheel in gear with the index wheel. This not only gears the cam wheel but times the detaching roller to begin delivery at 6.

Turn cylinder round until index is at $6\frac{3}{4}$, and then set the lifter cams, so that the leather rollers just reach and touch the fluted segments at that moment; slips of paper testing the clearance which should now obtain between roller ends and lifter tops. With this effect produced the lifter cams must be secured to the cam shaft. In setting, the cam may be turned round with one hand, while the other hand tests the paper clearance.

Now turn the index to 9, loosen the nipper cams, place a slip of paper between the nipper stop-screws and the nipper stands. Turn the nipper cam round until the paper loosens, and then fasten the nipper cam so as to fix the nipping at 9.

Then turn index to $4\frac{3}{4}$, loosen the top comb cam on the cylinder shaft, place slips of paper under the top comb setting screws. Turn cam or eccentric round until the paper is held tight between the set-screws and nipper stand, and then fasten the cam or cams to cylinder shaft. This causes top comb to drop at $4\frac{3}{4}$.

Re-starting.

For the time of feeding, turn until index is at 5 to $5\frac{3}{4}$ and then set feed peg to begin turning the star wheel of five notches.

Finally, all timings should be checked, all wheels properly geared, all covers in place. Comber well cleaned and oiled. Listen if any tins or covers are rubbing and comber is turned round. It is best to run the machine without cotton for a short time, to get all loose fibres out of waste brushes, especially if they are new; this also brushes out the cylinder needles well.

As soon as things appear to be correct, start the cotton through, note how the individual slivers come out, and also how each head delivers its waste to the back, as sometimes brushes may not be acting well.

Sliver at the front, and waste at the back, leaving the comber in good condition, the waste per cent. should be tested.

Stop comber, break off the waste clean up to doffer combs, break off the sliver clean up to nip of the dumb-bell calenders, run comber for thirty or more nips and then carefully and exactly gather both waste and good sliver. Weigh on a per cent. balance or on ordinary scales and obtain per cent. waste by usual methods.

Suppose 15 per cent. waste is disclosed and 17 per cent. is wanted. First test all the chief and central settings to see if any have altered, and if these are found correct then some timing alteration may be made.

The rule is: feed later and nip later to increase the waste per cent. Also to drop the top earlier will give more waste. Putting more angle in top comb gives more waste, but this is a setting rather than a timing.

Assume we are feeding at $5\frac{1}{4}$ and we now make it $5\frac{1}{2}$ of index. Also alter the nipping time from 9 to $9\frac{1}{4}$. The top comb already dropping at $4\frac{3}{4}$ may be considered early enough.

Above changes would be likely to give effect desired.

Small variations in waste per cent. are nearly always obtained by timings as these are more quickly altered.

Larger variations as from 12 to 18 per cent. would need settings altered, such as widening the distance from feed roller or cushion plate to steel detaching roller.

Items.

1. Sometimes a good deal of trouble in combing is attributed to the circular waste brushes. The action of these brushes releases into the atmosphere dust and fluff which dirties the machine and often gets into the combed sliver. The Roth aspirator retains the brushes but dispenses with the doffer, and draws the dust and fluff away from the combed sliver.

2. Really good cotton yarn requires equality in length of cotton fibre, clean fibres, and parallel fibres. The card is not sufficiently good in these respects for the best yarns, but good combing gives the result desired. The comber, however, must have a lap feed and preferably one in which there will be no trace of individuality of slivers in the front collecting tin of comber. The ribbon lap machine is best for producing a homogeneous cotton sheet for the comber, besides reducing the waste per cent. of comber by 1 per cent. or so without detriment to sliver.

3. There has been frequent argument *re* relative merits of fibre and bristle brushes for combers.

It is possible that fibre brushes will clean without penetration into cylinder needles, and sometimes breakages of the eighty tooth wheels have been traced to heavy work imposed by setting bristle brushes to penetrate cylinder needles in order to get thorough

cleaning. Sometimes brushes have been reversed in order to get a longer life. Variation in fibre thickness offers some little objection to fibre brushes.

Good bristles will probably wear more evenly and give way to the needles when contact is made.

Fixing of Needles to Foundation. Construction of Needle Segments or Half Laps.

In needle setting, the needles are rapidly put into a gauge by hand, with points down.

The holder or matrix is then placed against the thick ends of the needles which are still in the gauge, and the needles are soldered to this holder before taking away the gauge.

Each matrix or needle holder is usually of brass, and is shaped so that it will fit very accurately in its proper position. It is necessary for the rows of needles to be concentric with the cylinder, to be in exact line with each other, and to be parallel with the cylinder shaft. When needles are damaged it is easy to remove a half lap from the machine, and to remove a row of needles in its matrix from the half lap for repairs.

Cylinder Needles.

For 80's to 120's or so the counts of wire as per the wire gauge may be as follows, starting at the leading or coarsest row :—

4	rows of	20's
3	,, ,,	22's
2	,, ,,	24's
2	,, ,,	26's
2	,, ,,	28's
3	,, ,,	30's
1	,, ,,	33's
17	rows.	

A second system as used for very fine work is given below :—

6	rows of	22's
3	,, ,,	24's
2	,, ,,	26's
2	,, ,,	28's
2	,, ,,	30's
2	,, ,,	33's
17	rows.	

Recovery of Long Fibre from Flat Strips.

Some spinning mills only professing to produce carded Egyptian yarns have yet installed small combing systems in order to treat their card strips to reclaim the long fibre often present in strips, especially in good flat strips with flats running at a good speed. Some firms having tried this system have finally discarded it.

Sliver lap machine and three Nasmith combers represent the additional machinery required, and, if desired, a ribbon lap machine may be added.

In the blowing-room the strips may be passed through sufficient machines to produce good level, clean laps, say possibly an opener and a scutcher. The laps are treated in a card in the usual way—either flat card or roller and clearer. The ribbon machine not being used, the carded slivers of strips are levelled up, and the fibres improved in parallel arrangement by passing through, one head of draw-frame with either six or eight ends up.

At the sliver lap machine in this example laps are made of 10½ inches wide ready for the comber. If the ribbon machine were used between the sliver lap and the comber then the draw-frame referred to could be dispensed with, and in that case the sliver lap machine would make narrower laps—possibly 9 inches wide to allow of 1½ inch spreading out at the ribbon machine. The Nasmith comber is well adapted to comb the strips, and produces slivers which may be blended at either the first or middle draw-frame in the proportion desired, say five ordinary carded slivers put with one combed strip.

Opinions differ as to the practical value of the above procedure, and it is affected by the first cost, the space available, the prices of strips and of raw cotton, the kind of cotton and of produced yarn; 100 lb. of strip may lose 17 lb. before reaching the comber and 23 per cent. at the comber.

Modern Heilmann Combers.

These are now made with very strong gearing ends, beams, and main supports; the headstock is built upon a solid cast-iron base plate and has two frame ends holding the planed table on which most of the gearing is fixed. A comber requires great rigidity and freedom from vibration, and above means are satisfactory in this respect. Wheels are mostly cut out of the solid, and most parts are made to templet and are interchangeable where necessary. Heilmann combers are mostly made with eight heads, but six heads are made if required. During the period 1895 to 1920 the 10½-inch lap became firmly established, although laps of 7½, 8¾ inches up to 12 inches are made if required.

Improvements in half laps or needle segments and ends of

nippers help to prevent excessive waste, due to lap selvedges being turned over double, and the needles being unable to comb the extra thickness of lap. Nippers are operated by two separate cams either on the same long rocking shaft, or with the rocking shaft in two halves, to prevent torsion in nipper shafts.

As regards the lifters the rocking shaft for operating these has been done away with by most firms, the lifter cams improved, and one used for each two heads, dispensing with some intermediate pins, levers, and brackets. The short top metal detaching rollers may be covered with brass if required, and in any case should have case-hardened pivots.

Main shafts at headstocks are often case hardened all over. There is a device obtainable, by which the circular waste brushes may be revolved while other parts of comber are stopped, in order to thoroughly clean out the cylinders and half laps. A sliding wheel readily permits the disconnection required.

Gearing Plan of Heilmann Comber.

(Messrs. Asa Lees & Co. See Fig. 46.)

Calculations.

To find the draft between the lap and the front calender :—

$$\frac{47}{35} \times \frac{55}{20} \times \frac{22}{23} \times \frac{38}{18}^{1} \times \frac{5}{1} \times \frac{80}{80} \times \frac{20}{142} \times \frac{2\frac{3}{4}}{2\frac{3}{4}} = 5{\cdot}25.$$

To find the draft in the draw box :—

$$\frac{\text{Back roller wheel (40 to 60)}}{16} \times \frac{\text{change wheel (30 to 45)}}{45} \times$$

$$\frac{45}{25} \times \frac{22}{39} \times \frac{2\frac{3}{4}}{\text{diam. of back roller}} = \text{draft in draw box.}$$

To find the total draft in the comber (without allowance for waste) :—

$$\frac{47}{35} \times \frac{55}{20} \times \frac{22}{23} \times \frac{38}{18} \times \frac{5}{1} \times \frac{25}{25} \times \frac{\text{draft change wheel}}{45} \times$$

$$\frac{45}{25} \times \frac{22}{39} \times \frac{39}{43} \times \frac{27}{20} \times \frac{18}{18} \times \frac{22}{20} \times \frac{2}{2\frac{3}{4}} = \text{total draft.}$$

[1] The 18's wheel can be changed, if desired, the range being from 12's to 24's.

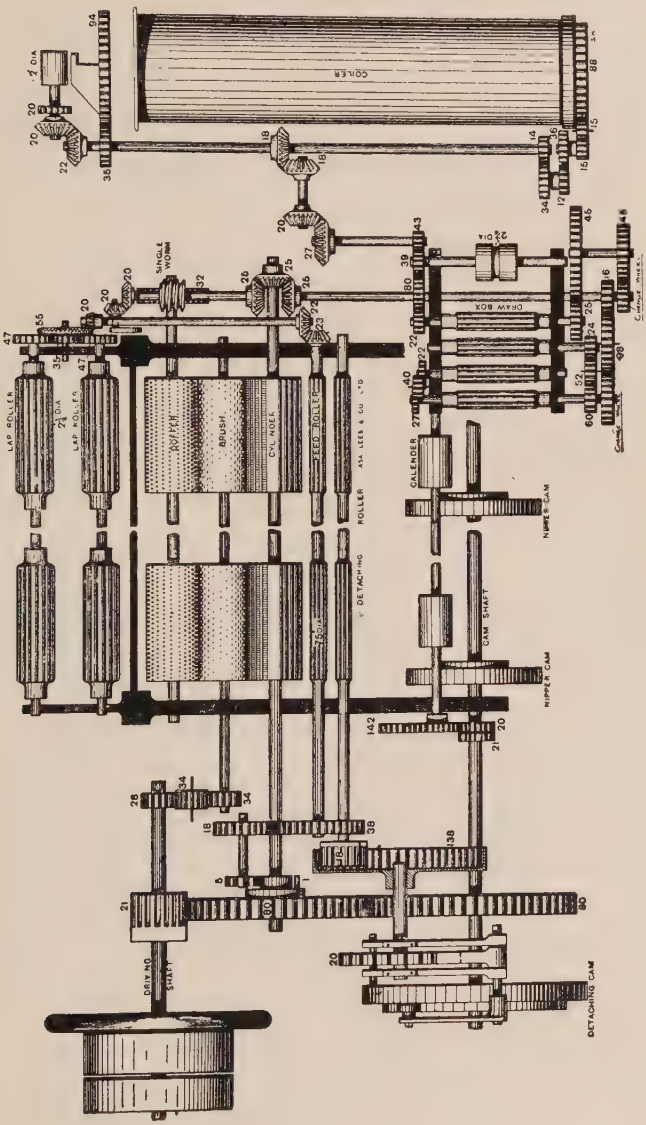

COILER
SINGLE WORM
DRAW BOX
LAP ROLLER
BRUSH
CYLINDER
FEED ROLLER
DETACHING ROLLER
CALENDER
NIPPER CAM
CAM SHAFT
DETACHING CAM
DELIVERY SHAFT

Fig. 46.

To find the length of lap fed per nip :—

$$\frac{1}{5} \times \frac{\text{change wheel (18)}}{38} \times \text{circumference of feed roller (2·35)}$$

$$= \cdot 22 \text{ inches.}$$

To find the production of the comber :—

$$\frac{\text{Weight of lap in grains per yard} \times \text{Nips per minute} \times \text{Length of lap fed per nip} \times \text{No. of heads in machine} \times 60 \text{ (minutes)}}{36 \times 7000}$$

= Production of comber (including waste).

To find the percentage of waste :—

$$\frac{100 \times \text{weight of waste}}{\text{weight of combed sliver} + \text{weight of waste}} = \text{percentage of waste.}$$

The top comb shaft in most Heilmann combers is operated by one cam on each end of the frame on the cylinder shaft, and it is the writer's experience that these two cams require careful setting to obtain equal action from both.

Half laps or needle segments can be taken out and repaired separately, and in case of serious damage may be replaced by interchangeable needle segments. Coilers of the fine spinning standard 9 inches inside diameter × 36 inches length.

About 330 r.p.m. is a good working speed for the main pulleys of about 11 to 12 inches diameter × 3 inches width. Production from 300 to 500 lb. per week of forty-eight hours.

At the drawing head either leather-covered or metallic top rollers may be used, and four pairs of rollers is a common method, although combers have been made with three pairs and others with five pairs of rollers.

Either inserted metallic clothing may be used for the doffers or the saw tooth in leather foundation. The loose ends for top rollers are much used for the draw box top rollers, although loose bosses are applied if desired. Ermen's revolving top clearer is much used at the draw box, but other kinds such as revolving top clearers or ordinary flats applied if desired. Fluted rollers case hardened in neck, only or all over as specified. In regard to automatic stop-motions the full can stop-motion is generally used, and on some combers stop-motions are also provided for stopping comber if a sliver fails between the draw box and the coiler top. Also if any one sliver fails between detaching rollers and first calenders.

Disposal of Waste.—At the back of the comber rectangular boxes are largely used to receive the waste, but there is the alternative

method of using a slowly revolving shaft for rolling up the waste in lap form.

The most ambitious method of disposing of the comber waste is to use Roth's aspirator, which dispenses with the doffers and draws the waste from the machine by means of an air current which also extracts a fair amount of fine dust or dirt.

In some cases mica plates are used on top of the back covers so that some of the central parts and the action of the waste may be watched while the machine is working. Mica plates are more liable to sustain injury than the usual strong tin covers, but not so likely to be broken as glass.

There is a quickly revolving circular brush for each head in order to clean the half laps, and when required, the efficiency of the brush action is improved by giving a slight longitudinal travel to the long brush shaft by a crank or cam arrangement somewhat resembling that for the long grinding roller of a carding engine.

The long front sliver tables must always be well polished, and it is best if these tables are nickel-plated.

When standing in front of the long table of comber the gearing end and driving pulleys may be either on the right hand or the left hand, thus fixing the hand of the comber.

Heilmann Comber for Fine Work (Fig. 47).

A former assistant teacher of the present writer's—Mr. J. E. Hayes—has co-operated for some years with an eminent machine shop in improving the details of the Heilmann comber in order to obtain better work and possibly higher speeds.

All seatings planed, milled, or turned to template to ensure good fitting and easy replacement. All spur gear wheels cut to ensure smooth and easy running.

Draft gearing arranged so that a single change of draft pinion alters draw box draft and speed of coiler at same time.

Electric Stop-motion.—The broken sliver and full can stop-motions are electrically operated, and provision has been made to ensure very quick knocking off. Electric stop-motion to each head. A large-size magneto electric machine is used to serve six combers. The makers claim that the electric stop-motion as arranged on this machine is very suitable for combers, as it is not easily disarranged, nor is it liable to become inactive through fly and dust accumulating, with the additional advantage of leaving the sliver plate free of spoons and levers.

Quadrant Motion.—While the action of the quadrant motion remains essentially as before, detailed improvements have been made to ensure greater stability and a more precise action. The quadrant and clutch are actuated by cams, all being very firmly

supported. The quadrant is centred close to and over the centre of the beam, and has a long bearing. It gears with a sliding wheel connected to the clutch box, which is fixed apart from the detaching roller. Owing to this fact a larger and stronger clutch can be used, and the possibility of side play and consequent cutting of fibres by the detaching roller is avoided. Another important new feature is that the clutch box and gear can be removed without disturbing the settings. An eccentric shaft permits a very fine adjustment, whereby the quadrant may be kept well in gear and free from backlash.

Cams.—The various cams are milled, and are exact duplicates. They are carefully distributed on the machine so as to minimise torsion in the actuating shaft, and, with this end in view, the cam-shaft is supported by a bearing near each cam. Hardened steel bowls and studs travel along the machine-cut pathways of the cams. To ensure all the parts moving together and to facilitate correct setting, and also to prevent any undue strain being placed on any particular cam or bowl, both the cam shaft and top-comb shafts are in two parts. Machine-cut cams.

Alterations are made in the detaching rollers, nipper frames, comb cylinders, lap creel, etc., and are intended to improve the combed sliver. The gearing end portion of the various shafts can be quickly taken out without disturbing the rest of the machine.

Because each combed head is narrower, smaller diameter detaching rollers are possible without detrimental deflection, and these smaller diameters permit closer settings. Top comb set as near to above rollers as possible to ensure always being down before detaching.

The comb cylinders are constructed on the circular barrel method, which permits changing of half laps with little trouble.

The needle strips, segments, and half laps are all interchangeable. Needles of best tempered steel.

Nipper frames. These have been altered and are mounted separately from each other, so that any individual frame can be taken out for re-setting without disturbing the frame itself, this enables each nipper to be completely re-set in the vice, ensuring better and quicker setting. The nippers and cushion plates along with top combs are more firmly fixed, the useless long thin ends liable to cause deflection are eliminated, and accompanied by improvements in the rollers, a wider lap may be dealt with possibly one inch or so wider. Selvedge guides are provided on both nipper frames and cylinders with good results. At 225 r.p.m. of the pulleys there will be 90 nips per minute.

Lap Creel.—This has been specially rearranged to reduce lap licking to the minimum. The height of the creel, the position of the fluted rollers, the angle of the lap plate, have all been altered

to avoid lap licking, eliminate slip, and give a steady feed. All parts of the machine, including cams and adjusting screws, have

FIG. 47.

been fixed in such a way as to be most easily accessible, and the gearing ends of the various shafts can be quickly detached without

disturbing the rest of the machine. In addition, means have been arranged for, whereby a separate adjustment for the forward motion can be made, and the necessity of having to ungear wheels and re-fix the nipper cams whenever the re-timing of the quadrant is altered is completely avoided.

The quadrant has been rearranged in its chief bearing so to obtain great steadiness and freedom from twist.

The electric stop-motion operates when funnels are choked, or roller laps form, or sliver breaks, or a sliver can is full.

With the circular barrel method for cylinders, a bed concentric with the axis of the cylinder is formed, and upon this the half-lap seats, being constructed with a concave face to correspond.

The top combs are fixed at each end of the machine to have all the tops lifting together, and both top comb and cam shafts are arranged to prevent undue wear of the cams; and also to give smoothness and rigidity of movement.

Circular brushes driven by an adjustable 3-speed gear to compensate for any wear of the bristles and having a longitudinal traverse motion.

CHAPTER V.

THE NASMITH COTTON COMBER.

Dating back to the introduction of the first Heilmann cotton comber, 1846-50, not one of the fundamental processes or machines used in cotton spinning has been more subject to attempted radical innovation than the comber.[1] Remembering this fact, the present writer was by no means enthusiastic in regard to the practical possibilities of the Nasmith comber when rumours in regard to it became current among the trade during the years 1902-3. Any doubts of its ability to satisfy the requirements of present-day users of cotton combers have, however, long since been dispelled ; and to-day the Nasmith comber has obtained a world-wide fame, has kept the makers always busy, and has met with a remarkable amount of practical success as a rival of the older Heilmann comber. We do not ignore the fact that many spinners of fine yarns yet prefer the Heilmann, and especially for the long, fine, and sometimes neppy Sea Islands cottons.

The success of the Nasmith is all the more remarkable when we remember the failure of such combers as the Imbs, Hetherington-Lecœur, Delette, and Alsatian to obtain any adoption amongst English cotton spinners. When surveying and considering the details and the accessibility of the central organs of the Nasmith, we confess to admiration of the design and the detailed arrangements of the machine.

Apart from this, we fail to see how Mr. Nasmith could have done anything at all with his ideas without having the Heilmann to build upon. We consider that a better designation would have been "The Nasmith-Heilmann." Mr. Nasmith has not introduced fundamentally new methods or principles of feeding, combing, and detaching the cotton, or treating the waste, but he has revolutionised the central organs in detail of construction and action, so as to obtain distinctly better effects in most of the central operations. For example, as in the Heilmann, so in the Nasmith, we have intermittent feeding of a short length of thin cotton lap through a pair of momentarily opened nippers ; then these nippers close upon the cotton fibres and hold them firmly while the "heads" of the fibres

[1] These innovations still continue (see Addendum).

are combed by the positive action of cylinder needles, which take away the noil or waste to the back of the comber; then the detaching rollers draw the combed cotton through a top comb to the front, for passage into the coiler can. The Nasmith, Whitin, and Heilmann combers all have the fundamental principles of (1) intermittent feeding; (2) cylinder combing of heads of fibres; (3) top combs, through the needles of which the "tails" of the fibres are drawn; (4) reversing action of detaching rollers in order to obtain the piecing and overlap of the cotton fibres, and (5) final delivery of long fibres into the front can, and waste to the back of the machine.

Simplicity of mechanism, accessibility of parts, smoothness of operation, freedom from breakdown, good overlap, and good piecing of the cotton, regularity of work performed, good productions, adaptability to different lengths of fibre—especially the shorter kinds of cotton; these are features which have made the Nasmith comber a successful innovation on a large scale in connection with the machinery of cotton spinning.

The Nippers.

To the eye and mind of a man already accustomed to the construction and action of the Heilmann comber, no part of the mechanism of the Nasmith presents more radical alteration than the nipper mechanism. At the gearing or headstock end of the Nasmith comber nothing catches the eye more than the crank-driving arrangement which takes the place of the large cams of the Heilmann, in giving the required movement to the nippers. A close examination of the parts and a comparison with the corresponding mechanism of the Heilmann reveal the following features:—

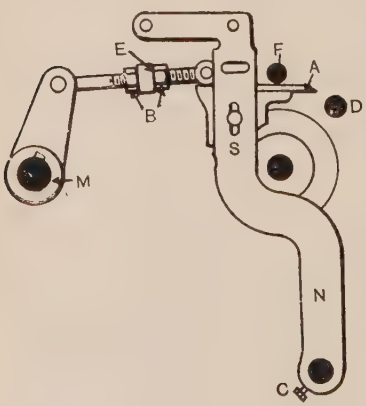


FIG. 48.

In the Heilmann it is quite possible for some such thing as a feed-roller lap to overcome the resistance of the springs and force the lower nipper or cushion plate into touch with the cylinder needles; this is not possible on the Nasmith. The leather cushion fixed in the lower nipper in some combers, and in the upper nipper in other combers, is absent from the Nasmith, because the nippers close so gently

that no appreciable injury results to the fibres through the absence of cushion. The Nasmith nippers, driven by a crank instead of cams, have a bold reciprocating movement which arrests one's attention, first to last, by the size of movement, the absence of noise, and the general effect of this movement upon all the central organs of the machine, such as the top comb, feed roller, detaching operation, and cylinder. Let it be understood at once that one result is that the nippers hold the cotton fibres at varying distances from the cylinder needles, and this is considered by some to be one of the chief features in which the Nasmith is not so good as the Heilmann, especially in combing Sea Islands cotton.

Adjustments of Nippers.

In explaining certain settings in regard to the nippers, it is proposed to use diagrams of the most simple character—assuming, first, that the crank and the slide-bar arrangement for driving the nippers is correctly adjusted, and that we have to deal with the parallelism of the nippers and the limit of movement of the nippers towards the detaching roller.

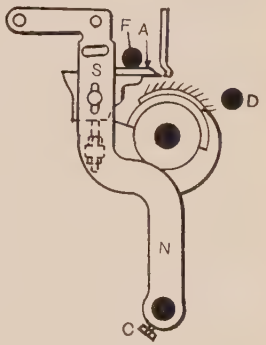


FIG. 49.

Referring to Fig. 48, the nippers are actuated from the long nipper shaft M through the medium of the screwed rod upon which are placed the nuts B. Backing one of these and following up with the opposite nut moves the nipper frame nearer to or farther from the inside bottom steel detaching roller D just as required. There are two screwed rod arrangements for each head, and by these means all the six heads may be set in like manner. Place the index at 19, and by the nuts B set the cushion plate or bottom nipper A parallel to the steel detaching roller D, at a distance of $\frac{3}{8}$ inch, all across the width of the head. Flat 12 on the official stepped gauge is the usual article for aiding in this adjustment. Take particular notice that the set-screw C at the lower or fulcrum end of the main nipper lever is quite loose, or otherwise the adjustment of the nipper at one head may affect the nipper setting at the next head. It is one of the excellent details of this comber that the main nipper levers work upon long studs of 1 inch diameter rocking in cast-iron bushes, so wearing or readjustment of these parts is very seldom necessary, and any renewals could be easily and cheaply made if required (see Figs. 48-49).

Adjustment of Nippers to Cylinder Needles.

For the purpose of setting the nippers to the inside of the detaching roller, the nippers are naturally placed in their most forward position, the index 19 being taken for this. An entirely different position of the nippers is required when setting them to the cylinder needles, so that the index is now turned to 33, at which tmie the nippers should be somewhere near the closest position in regard to the cylinder needles, and not far from their greatest distance away from the detaching rollers. Care should be exercised here to have the main fulcrum set-screws C tightened up, to ensure the former setting of the nippers to detaching rollers remaining undisturbed. The nipper springs should be on, but no cotton in the head.

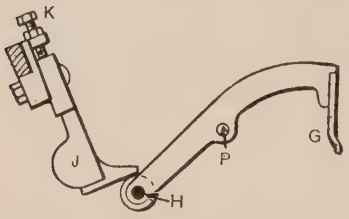


FIG. 50.

At this time also the bowl at H in Fig. 50 should be clear of its incline, and the screw S loose. The gauge established as the best for this setting of the nippers to the cylinder needles is a doctor or feeler gauge, equal to $\frac{25}{1000}$ inch in thickness.

Time of Opening Nippers and Amount of Opening.

In the Nasmith comber the nippers are opened by the upper jaw leaving the lower one, as in the Heilmann, but the lower does not follow the upper one at all, while the method and mechanism for opening the nippers is much more simple than in the Heilmann. The nippers must be closed when occupying their nearest position to the cylinder needles, which is very near the end of the backward stroke, and they must be opened for detaching when near the limit of the forward stroke to permit of detaching.

Referring now to Fig. 50, the upper nipper lever has its fulcrum P about midway from G to H. When the nipper is moved forward it is also lifted higher owing to the disposition of the main nipper fulcrum at C (Figs. 48 and 49). This lifting of the nippers brings the bowl H against the adjustable incline J, so as to force H downwards and the upper nipper G upwards, away from the lower nipper. With the index at 27 the leg J should be adjusted until the incline just touches the bowl H, which is in the middle of a rod stretching across the head. This makes the time of opening correct. To fix more accurately the amount of opening, the index is again moved to 19 so that the nippers now occupy their front position and are required to be open for detaching. Now place a gauge $\frac{3}{8}$ inch thick

between the jaws of the nippers, loosen the bolt which connects the incline to the leg J in Fig. 50, and work the incline about until its point touches the bowl H.

Generally speaking the nippers are best opened late, but if this idea is carried to excess the lap may be struck from the teeth of the top comb when the nippers close. An insufficient opening of the nippers may give a defective piecing.

Double Fulcrumage of Upper Nipper.

The fulcrum of the upper nipper is upon a stud which is carried about with the general movement of the nippers, so that each upper nipper has its own movable fulcrum, and also swings about on the fulcrum of the main nipper lever as at C, in Figs. 48 and 49. One practical result of this connection is that the nipper springs exercise only a moderate tension as the nippers close upon the cotton, and this closing action is sufficiently mild to warrant the exclusion of any leather cushion on either of the nippers. The continued movement of the bowl H in Fig. 50 away from the incline and leg at J, puts a considerable tension on the nipper springs when the fibres are nipped for cylinder combing. The ribbon machine to precede the comber is in very general use for the Nasmith comber as it not only makes thick lap sheets very conveniently but also gives a very homogeneous and uniform lap sheet.

The index plate is divided into 40 parts, every fifth mark being numbered 5, 10, etc., up to 40.

The Cylinders. Base Setting.

At index $2\frac{1}{2}$, set the cylinders in the middle of each head and screw them tightly on the shaft so that the front edge of the plain segment is to gauge No. 1 ($2\frac{1}{2}$ inches) from the back of the steel detaching roller (Fig. 51).

A. The bearings of the roller D, if disturbed, should be set to the mark on the stands; it will then be at the proper distance from the plain segment. The set screws for fastening the cylinder are discovered by removing the tin strip behind the last row of needles.

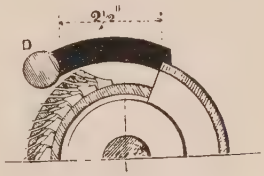


Fig. 51.

B. After setting the cylinders, put on the front calender and the table and set the brush tins to clear the cylinders equally at the back and front and at the ends, so that the top edge of the tin is $\frac{1}{16}$ inch from the under side of the inner steel detaching roller.

Fig. 52 is introduced in order to aid in understanding some of the

workings and settings of the Nasmith comber, and is accompanied by brief description.

The nipper shaft W is rocked too and fro by the main driving crank at gearing end of comber, and is connected to the nipper bridge S by the arms W′ and connecting rods V—two to each nipper —with adjusting nuts V′ so that the nipper jaws may be set parallel to, and at the proper distance from the detaching roller D. Once all the nippers are correctly set, their distance from roller D may be altered for all the comber by means of the adjusting screws of the crank arm at end of comber. The nipper bridge S is bolted at each end to an upright N secured to a stud N′, which rocks in a bush carried in the framing. The top nipper arms pivot on studs

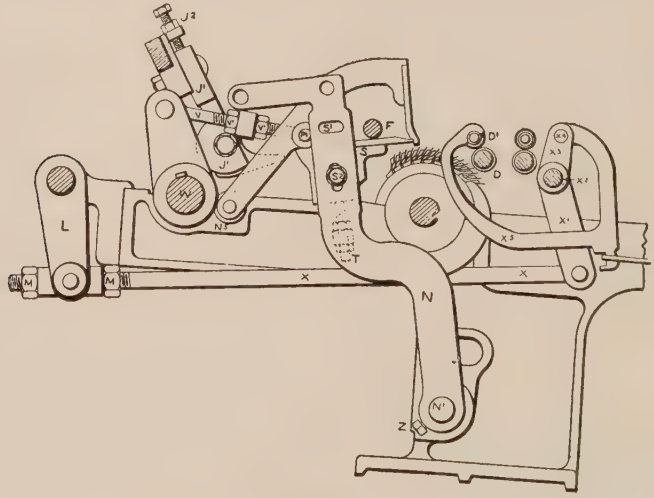


FIG. 52.

P^1 carried in projections cast on the bridge S. At the lower end of the arm a cross-bar carries a bowl N^5, which comes in contact with the adjustable incline J and opens the nipper as it moves forward. When the nipper moves back for combing (Fig. 52), this bowl leaves the incline J, and the nipper closes under the influence of springs attached to the lower end of the nipper arms. There is little pressure on the springs when the nipper is opening, but a strong pressure when closed during combing. The opening and closing thus takes place gently and without the detrimental hammering blow observable in the Heilmann and other combers. The nipper is adjustable to the needles by set-screws T (Fig. 52), and one set is a fixture and cannot be made to touch the cylinder, as its path if

continued in both directions never intersects the circumference of the cylinder.

The Feed Roller.—Each nipper carries its own feed roller F, (Fig. 52), which is adjustable on the nipper plate, so that its distance from the jaw of the nipper is easily set to suit the length of the fibre operated on. The roller receives its rotation from the movement of the nipper through a ratchet and pawl. The roller turns inside a stationary bush, and the ratchet lever rocks on the outside of the bush, so there is no contact between the roller and ratchet except through the pawl, the whole being enclosed in a casing to exclude fluff and dust. There are no change wheels, the amount of feed being altered by the simple displacement of a stud.

Heilmann v. *Nasmith for Short Cottons and Heavy Lap Sheets.*

In the Nasmith comber, as compared with the Heilmann, it may be stated that the time for detaching the cotton and drawing it through the needles of the top comb is greatly prolonged. Also there is no need to have the surface speed of the detaching rollers exactly the same as that of the cylinder in the Nasmith, but this equal speed is necessary in the Heilmann. The continued dropping of the leather detaching roller upon the fluted cylinder segment, and the abrupt detaching action are not necessary in the Nasmith. The nippers, the top comb, and the feed roller move towards the detaching rollers during detaching, and this helps in the piecing. There is a comparatively long overlap of the cotton obtained when making the piecing on the Nasmith, more than double the amount of overlap in making the Heilmann piecings, so that better piecings are obtained in the Nasmith. The thickness of the leather roller must be interposed between the steel detaching roller and the nippers and feed in the Heilmann, but this is unnecessary in the Nasmith, so that the parts can come closer together. The long overlap of the piecings, and the possibility of the nippers and feed coming close to the long steel detaching roller help materially in adapting the Nasmith comber to short staple cotton. The prolonged period of detaching and the mild manner of this work, combined with rearrangement of parts, enable a very heavy weight per yard of lap to be used at the Nasmith, while the nips per minute are at least as many, so that production is easily increased to a very great extent. In the Nasmith one feed roller only is used, as against two in the Heilmann. There are four detaching rollers in the Nasmith, and only three in the Heilmann.

Combings per Fibre.—It has been contended that the same number of combings per fibre are not obtained from the Nasmith as from the Heilmann, due to the difference between the lengths delivered on the two combers during detaching. To put it

another way, it is contended that increased length of cotton delivered per nip is obtained at the expense of cylinder combing. As a matter of fact, assuming the same distance from the front edge of the cushion plate to the detaching point, and having similar lengths of fibre in each instance, then the number of combings per fibre is the same in each case. The combings per fibre may be four or five in each case, but apparently a more thorough combing action is obtained from the Heilmann cylinder than from the Nasmith. The extra length of sliver obtained from the Nasmith is due to the greater drafting action of the detaching rollers, operating upon a much heavier lap sheet.

Nasmith v. *Heilmann.*

A. The Heilmann up to the present has a more effective cylinder combing action, especially when operating upon Sea Islands or any neppy cotton. As a consequence, the Heilmann has its chief superiority in its ability to make fibres parallel, to thoroughly clean the fibres, and in the extraction of nep.

B. On the other hand, the Nasmith is much the better machine in regard to detaching and piecing of the combed cotton. It is much superior to the Heilmann in regard to the work of the top comb, permitting the use of the double top comb more readily than does the Heilmann, and perhaps needing it more. The drawing out of the fibres between the feed and detaching rollers is much more powerful on the Nasmith, and permits the use of a much heavier lap sheet, while maintaining the same density of fleece passing through the top comb. The Nasmith top comb is much more effective than the Heilmann.

Efforts are being made to obtain the superior cylinder combing of the Heilmann combined with the superior detaching and top comb action of the Nasmith.

Oiling and Cleaning.—The use of good oil, carefully and systematically applied to the proper places, is of the utmost importance in the life and good working of all cotton machines, and this is specially true of the Nasmith comber, because of the high speeds of parts and the heavy weight of cotton often passed through the machine in one week.

The numerous bearings about the nippers, the steel detaching rollers, the various gearings, the brush shafts, and the cylinder shafts, should be oiled every week. Pivots of leather-covered detaching rollers may be wiped daily, and oiled a very little by the finger dipped in oil. Although the leather-covered detaching rollers do not have a higher speed than those of the Heilmann, yet they continue each nip to rotate for twice as long as on the Heilmann. To obtain good work from Nasmith combers, the detaching rollers

and top combs must be accurately adjusted, and maintained in excellent condition.

The Fly-wheel.—The fly-wheel is compounded with the fast pulley both on the Nasmith and Heilmann combers, and on the Nasmith is usually only about half the size of the Heilmann. On the Nasmith the fly-wheel is usually fixed on the outside of the fast pulley, and sometimes this is true of the Heilmann, although on many Heilmann combers the fly-wheel is fixed on the inside of the fast pulley. The writer prefers the outside method as being easier to get at, and also having the fly-wheel to guard the belt. The fly-wheel is very convenient for hand turning, and the heavy fly-wheel of the Heilmann is also conducive to steady running.

Construction.—It appears advisable to enumerate a few constructional details. The Nasmith occupies the same space as a Heilmann of the same number of heads and width of lap, 10½ inches being the usual width. The Nasmith stands 4 inches lower, which is in favour of the tenter. There is no leather covering required on the nipper, and when the nipper is once accurately and firmly adjusted it cannot be made to touch the cylinder. A feed roller lap may cause the latter mishap on the Heilmann.

The headstock is cast in one solid piece, with all the gearing enclosed in a close-fitting steel cover. The bearings of the cylinder, nipper shafts, and detaching rollers are split bushes of standard size, easily renewable. The nipper pivots are plain studs in cast-iron bushes, easily renewable. The brush and doffer shafts can be lifted straight out behind without disturbing anything else.

There is a suitable weight-relieving motion for the leather-covered detaching rollers. The front plate extends backwards to the detaching rollers so as to cover the calender shaft. The drawing head contains four rows of rollers. A selvedge guide between the detaching rollers prevents ragged selvedges on the fleece of cotton.

Working Experiences.—1. *Starting up of Laps.*—On a Heilmann the possession of top and bottom feed rollers makes it quite easy and definite to begin passing a lap end through the central organs. On the Nasmith there is only one feed roller at each head, and even a person accustomed to the Heilmann comber may find it slightly awkward at first to pass a lap through on the Nasmith, because the one-feed roller has not got the drawing power on the lap that exists on the Heilmann. Tenters, and even foremen, at first may find this matter slightly troublesome on the Nasmith. To pass laps through, it is good practice to have the nippers in the position nearest to the detaching rollers. Bring the end of the lap forward, lift up the end of the feed roller, and push the end of the lap beneath the roller; then turn the feed roller until the lap end is passed through the nippers.

When piecing laps before reaching the nippers, it is even more important on the Nasmith than on the Heilmann that care be taken to have the minimum amount of overlapping of the lap ends. The feed roller is easy to lift out in order to clean the nipper. By lifting up the ratchet catches of the feed and lap rollers the machine may be run bare and the cylinders brushed out without breaking the laps.

2. *Weight Placed Upon the Detaching Rollers.*—It is quite usual to hang 40 lb. weight from the ends of the leather-detaching rollers of the Heilmann comber—i.e. 20 lb. from each end. In a 10½-inch lap experience has proved that such weight is necessary if a really good grip of the cotton fibres is to be obtained. Weights of 25 lb. are usually deemed sufficient to hang from the detaching rollers of the Nasmith, but the writer has known of cases in which very weak slivers were obtained by using only 25 lb. weights. An effective remedy was obtained by using either one or both of the extra 5 lb. weights sent with the machine, and which will neatly fit over the solid weights.

It is just as important on the Nasmith as on the Heilmann to maintain the leather-covered detaching rollers in a well-covered and well-varnished condition. The second top leather-covered detaching roller is only very lightly weighted on the Nasmith. The method of weighting the inner or chief leather roller is not near so direct in method or connection on the Nasmith as on the Heilmann, and the actual pull of the weight on each end of the top roller of the Nasmith is quite considerable.

3. *Timings.*—There is not the same latitude, nor perhaps the same necessity, for alteration in the timings on the Nasmith as in the case of the Heilmann. Percentage of waste is often altered on the Nasmith by altering the distance of the nipper from the detaching roller. This alteration is quite easy, but it is not so easy to make the corresponding alteration in the top combs, since they can only be altered one by one. The question may be asked: Is not a slight alteration of feed, as on the Heilmann, after all, a better method? For example, there was a particular case of a Nasmith comber making much more waste than required, and alteration of the setting above mentioned did not produce the results desired. Finally, it was found that the detaching roller was moving forward a little too late, and this being corrected, the waste per cent. became all right. This kind of alteration has been tested on other Nasmith combers, and some very distinct effects have been produced in regard to waste percentage.

A mill director told the writer they had both kinds of combers, and they were able to get more per pound for Heilmann waste than for Nasmith, but he was unable to say why. At another mill both wastes sold at same price.

FIG. 53.—Chief gauges used in setting the Nasmith comber.

4. *Top Combs.*—Top combs on the Nasmith require a great deal of attention. To guarantee the best results they should be examined almost every day by the comber overlooker, and they should be frequently picked by the tenter. Choking of the top comb is sometimes a serious trouble and a possible explanation of this fault may be stated as below. As the nipper, feed roller, and top comb swing back together, there is no gain of distance by the nipper such as there is in the Heilmann due to the setting of the stepped gauge. The nipper does not gain on the top comb.

Needles of Top Comb.

For Egyptian and good staple American the customary top comb of 28's wire gauge in the needle, and sixty-six needles per inch does very well. Some attempts at using the finer and closer needles of Sea Islands cotton for above cottons, have resulted in too frequent needle breakage.

For the finest cottons and counts of yarn and lightest of lap weights per yard 33's gauge of needle, and eighty-one needles per inch are sometimes recommended for top combs, but are not to be recommended for coarser conditions. For the detaching rollers, want of alignment, binding in long bearings, need for varnishing, and imperfections in the leather, have often given a curliness to the slivers.

It has happened that attempts to get closer settings in the nipper knives of combers, have resulted in the laps being plucked right through the nipper, and ordinary settings have been used again.

In regard to the Nasmith attempts have been made to get the nipper to swing in a path which shall be concentric with the cylinder.

The first public reference to the Nasmith comber—apart from patent records—was given at the end of the present writer's treatise on combing machines in 1902. From June, 1902, to end of August, 1904, Messrs. Hetherington erected over 350 Nasmith combers for various spinning firms, while before the end of 1917 over 6,000 of these combers had been built and started by above firm. For some time other firms have made the Nasmith, and the number at work has greatly increased.

The Heilmann comber increased the possibilities of cotton spinning, and enabled counts and qualities of cotton yarn to be produced that otherwise would have been commercially impracticable. The Nasmith comber has again increased the scope and possibilities of the cotton fibre in two or three distinct ways. In the first place, for many sorts of work the Nasmith comber permits of cheaper combing by reason of its greater production. In

the second place, the Nasmith comber is capable of dealing with shorter-stapled cotton than the Heilmann. The latter machine is admirably adapted for dealing with cottons whose average length of fibre is not less than $1\frac{3}{8}$ inch, but the Nasmith is capable of dealing with ordinary American cotton of only about 1 inch average length.

Cleaning Capacity of Combers.

In regard to actual combing and cleaning of the cotton fibres, the position may be summarised by stating that the Heilmann has a better capacity in regard to treatment by the cylinder needles, and the Nasmith in regard to treatment by the top comb. The cylinder needles, of course, operate chiefly upon the heads or front halves of the fibres, while the top-comb needles operate chiefly upon the tails or rear halves of the cotton fibres.

To deal first with cylinder combing. The lap used on the Nasmith is usually 20 or more dwts. per yard, as compared with about 13 dwts. on the Heilmann. The cylinder needles pass somewhat rapidly through the tufts of cotton fibres held by the nippers, and it is always a disadvantage to comb a heavy lap, because there is a tendency for the fibres to ride upon the points of the cylinder needles at the points nearest to the holding point of the nippers.

The difficulty is increased in the Nasmith comber by the swinging motion of the nippers above the cylinder, which gives a varying distance between the cylinder needles and the nipping point. In certain tests it was noted that the distance from the nippers to the cylinder during one passage of the cylinder needles varied from 0·042 to 0·025 inch, at least partly explained by the nipper frame swinging about upon arms or levers which have a 10-inch radius, while the needle segment has only a $2\frac{1}{2}$-inch radius. A disadvantageous withdrawing of the lap fringe from the needles thus occurs when the fine back rows of cylinder needles are coming into action.

Attention appears to have been given to experiments with a view to obtaining a swinging movement of nippers more nearly concentric with the cylinder needles.

There is another point which also appears to exercise some influence upon this fundamental principle of combing by the cylinder needles. Taking the Heilmann and Nasmith combers at equal revolutions per minute, the diameter of the Nasmith cylinder at 5 inches and the Heilmann cylinder at $4\frac{1}{4}$ inches, the cylinder needles of the Nasmith pass much more quickly through the cotton fibres than do the cylinder needles of the Heilmann, and this is not a good thing for delicate cotton fibres, especially Sea Islands cotton. In a particular example it was estimated that the greater speed of

the Nasmith needles equals 17½ per cent. due to diameter and 18 per cent. due to backward swing of nippers, giving a total of 35½ per cent. quicker speed rate for the Nasmith at a precise relative position of these parts.

We do not suppose that anyone will argue that the seventeen rows of needles on the cylinder do seventeen times as much work as the usual one row of needles on the top comb, but in any case their combing value is very great and must always be recognised. The action of the cylinder needles is of a positive character, while that of the top-comb needles is of a negative character. The cylinder needles are drawn through the fibres, but in the case of the top comb it is the cotton fibres that are drawn through the needles. Combing of tails of fibres is done by the top comb.

The Heilmann is yet a good machine for neppy Sea Islands cotton, and for the finest and highest qualities of combed yarns. In most respects the writer is of opinion that for Egyptian cotton the Nasmith is the coming machine, so that the important element of cylinder combing requires to be borne in mind in favour of the Heilmann. In regard to cylinder combing, the Nasmith has a higher speed of needles through the fibres, it has an uneven speed of needles through the fibres, the needles are at varying distances, there is a withdrawing of needles when the finer ones are coming into action, and, with all this, a heavier lap is treated. These remarks refer to present constructions.

The Top Comb.

Fig. 54 represents the various parts belonging to the top comb, along with adjacent parts. In both the Nasmith and the Heilmann combers the top comb is an interesting mechanism to study, in regard both to construction and to operation.

The writer is of opinion that the Heilmann comber is not up to the Nasmith in regard to the amount and quality of work obtained from the top comb.

Adjustments.—Referring to Fig. 54, the screw D permits the top comb A to be lowered or raised in relation to the cylinder. The screw C is for adjusting the angle of the top comb. The larger side screw at B permits the top comb to be properly adjusted to the detaching rollers R, while the time of raising and lowering the top comb may be somewhat varied by the bowl E coming on or off the inclined rim F. All these four adjustments have their counterparts in the Heilmann.

Distance of Comb.—Fig. 55 is intended to assist in explaining the setting of the top comb A to the inner steel detaching roller S (Fig. 55). The index should be placed at 19, at which timing the top comb and nippers are supposed to occupy their most forward posi-

tion. As shown in Fig. 55, a trowel gauge T, $\frac{1}{16}$ inch thick, is used, and the top comb A set parallel to and $\frac{1}{16}$ inch away from the inner steel roller S, all across its width, the slots at B (Fig. 54) permitting this.

Angle of Top Comb.—On the Heilmann comber a good deal is sometimes made of adjustments of the top comb, and two sorts of angle gauges are extensively used. The dictum is established of more angle, more waste. Judiciously and moderately used a certain amount of benefit may be obtained from this practice, but the official view in regard to the Nasmith is to get a good working angle and then leave it alone. In the official set of gauges handled by the writer no angle gauge at all has been supplied by the makers, and no degrees of angle are given in the makers' booklets. An average basis for angle is to have the ends of the top arms at B (Fig. 54), projecting about $\frac{5}{8}$ inch beyond the upright arm A of the top comb, and the angle should then be about correct. The operator should use only one angle screw when making the adjustment, the other being screwed out of action for the moment, to be returned when the correct setting has been obtained.

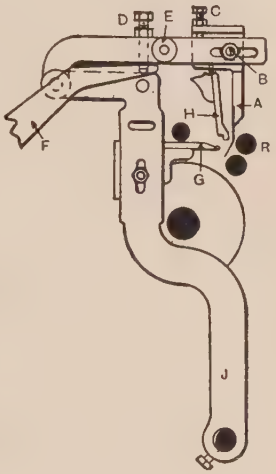


FIG. 54.

For setting the depth of the points of the needles of the top comb, an entirely different method is adopted from the Heilmann comber, in which a trowel gauge is used to get the needle points the correct distance from the fluted segment of the cylinder. In the Nasmith comber, as shown in Figs. 54 and 55, a plain, thin feeler gauge or doctor gauge E, $\frac{6}{1000}$ inch thick, is simply laid upon the two bottom steel rollers S, R, as in Fig. 55. Then, by means of the right-hand screw D (Fig. 54), the comb is lowered until the needle points press down upon the gauge sufficient to lift it about $\frac{1}{8}$ inch off the outer steel roller R, as shown in Fig. 55. During these two important settings the bowl E (Fig. 54) should be clear of the incline F, but this incline and bowl take the weight of the comb when it is lifted during cylinder combing.

Comparison of Top-Comb Actions.

In the Heilmann comber the top comb is stationary during all the time the cotton fibres are being drawn between its needles.

From 5 to 9 of the 80-tooth index wheel is a common duration for the work of the top comb, and the whole action is quicker and more abrupt than is good for the work. Experience proves that feeding and detaching should proceed together for the best results on the Heilmann, and slack cotton between the feed roller and top comb, due to early feeding, should be rigidly avoided. The top comb is always required to perform the dual operations of holding back nep, fine impurities, and short fibre, while also straightening the fibres.

In the Nasmith comber there is the loom-like effect of the nippers, feed roller, and top comb sweeping backwards and forwards through a space of 2 inches or so, quite apart from the opening and shutting of the nippers and the raising or lowering of the top comb. It is this simultaneous oscillation which is at the root of the vastly improved effect obtained from the top comb in the Nasmith comber. The operations of detaching and drawing the fibres through the needles of the top comb occupy a relatively much

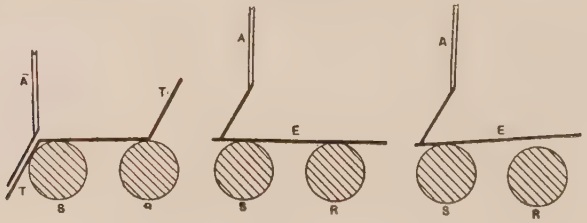


Fig. 55.

greater proportion of time in the Nasmith, so that, in spite of the relatively heavy amount of feed, the speed of the fibres through the needles of the top comb is actually much slower on the Nasmith than on the Heilmann. The heavier production customary from the Nasmith, as well as the improved top-comb action, is largely due to the progressive and extended period of detachment, taking up about three times as long a proportion of each cycle of operations as it does on the Heilmann, the proportion being about $\frac{1}{10}$ of the total period for the older machine, against about $\frac{3}{10}$ on the Nasmith. So long as the heavier lap does not prevent perfect penetration of the top-comb needles into the lap sheet, the very thickness of the lap helps in straightening the fibres.

As heavy a lap sheet could not be fed at the Heilmann as on the Nasmith, because there would be too many fibres crowding the top-comb needles, and there is not sufficient ability to reduce this crowding by draft between the steel feed rollers and steel detaching rollers. It is well also to remember the rolling action of the inner top leather detaching roller in this connection, and that the cylinder

is without fluted segment on the Nasmith, because these details are all more or less associated in obtaining the prolonged and progressive detaching and top-comb actions which form the basis for increased productions.

If fibres are to be drawn through the needles of the top comb, their heads or leading ends must be gripped by the detaching rollers in order to overcome the resistance of the top-comb needles. The frictional pull of other fibres is not alone sufficient to draw many fibres through the top comb.

Beginning with the index at 11, approximately the top-comb needles are $\frac{13}{16}$ inch away from the nip of the detaching rollers. The top comb may have a forward movement during each cycle, equal to about 8 of the index in time, and to about $\frac{17}{32}$ inch in extent; at the same time the inner top detaching roller (the only one of the four rollers having bodily movement through space) may recede about $\frac{18}{32}$ inch. In this way about $\frac{17}{32}$ minus $\frac{6}{32}$, or $\frac{11}{32}$ inch of fibre length, may be fed every time.

The surface speed of the detaching rollers is much greater than that of the feed rollers in both types of comber, but this drafting effect is conveniently made about $8\frac{1}{2}$ on the Nasmith, compared with $4\frac{1}{2}$ to 5 on the Heilmann. The fact remains that the cotton fibres are being drawn through the top needles for a comparatively long period. The fibres are subjected, as stated, to a draft of about $8\frac{1}{2}$ or so between the feed and detaching rollers, compared with only about $4\frac{1}{2}$ to 5 on the Heilmann in this position. This large draft represents a more prolonged yet more gradual drawing of the cotton fibres through the needles of the top comb, adding to the value of this comb, and exercising a great effect in obtaining a heavy production from the Nasmith.

Simple Details of Mechanism.

1. *Driving of Doffer Comb.*—This little drive is of the simplest possible character, as will be seen from Fig. 56. The upper arm of the arrangement is set-screwed at A to the outer or coiler end of the long nipper shaft. The link-rod B connects the upper arm with the lower arm C, slots for adjustment and for length of stroke being provided in both the upper and the lower arms. The comb E is set-screwed to the long shaft F, which runs the length of the machine, and is supported by suitable bearings. In the Heilmann comber one method is to extend the worm shaft which gives the slow revolution to the doffer, and to operate a small crank and crank-lever arrangement which is directly coupled to the long shaft of the doffer comb and gives the required movement.

2. *Weighting of Feed Roller.*—In the Heilmann comber there are always two feed rollers, but in the Nasmith comber there is

only one feed roller for each head. There is also the very distinctive feature that each feed roller is independently driven and adjusted, there being no long bottom feed roller common to all the heads.

Each cap or bearing B has its own fulcrum at D, where it is connected to the swing arrangement, and the feed roller is held in the manner shown in Fig. 57. The spiral springs—one at each end of the roller—hold the lever A firmly downwards upon the cap; but the lever A may be readily turned over on its fulcrum C in order to liberate the feed roller and permit it to be lifted up or taken out.

The Feed Roller.—On the Nasmith comber the construction and driving of the feed roller are entirely different from the construction and driving of the feed roller on the Heilmann. Advantages and disadvantages are neither all with one nor the other method, but it appears obvious that the continuous length of the bottom feed roller universally adopted for the Heilmann could not be adapted

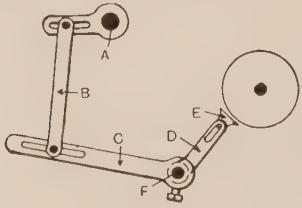


Fig. 56.

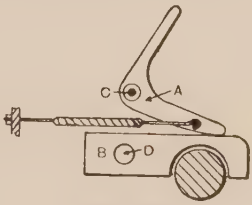


Fig. 57.

to the Nasmith, in which the feed rollers swing about with the nippers and top comb.

It is a great convenience on the Heilmann to be able to move the feed peg quickly in its slot so as easily to vary the time of feeding sooner or later and to the exact amount desired, although this convenience is sometimes abused. Moreover, the feed change-wheel can readily be altered on the Heilmann so as to increase or diminish the amount of feed per nip to suit any specific requirements. In the writer's opinion, it is also an advantage on the Heilmann to have the fluted wood lap rollers driven from the long bottom feed roller, so that whatever is done to the steel feed rollers in altering the time and amount of feeding, a proportionate alteration also takes place upon the lap rollers.

On referring to Fig. 58 the method of driving the feed roller, and also the method of altering the amount of feed, may be readily understood. Each feed roller F has secured to one end a ratchet-wheel B. The casing A is loose on the feed roller end, and is part of the upright arm E, which is fulcrumed at G to the link D.

The link D is loosely hinged at its other end upon a long thin rod, which also serves as a back rest for the front polished lap tins, and also for loose fingers intended to hook up the top combs out of action. C is the catch for imparting movement to the feed roller. The feed roller wheel B is taken through space with the nippers, and so also is the catch C, but the wheel is moved through a greater amount of space than the catch, owing to the catch being nearer to the fulcrum G of the upright finger K.

The mechanism is designed to feed $\frac{1}{4}$ inch of lap fringe for each nip, when the finger D is linked in the central hole of the upright

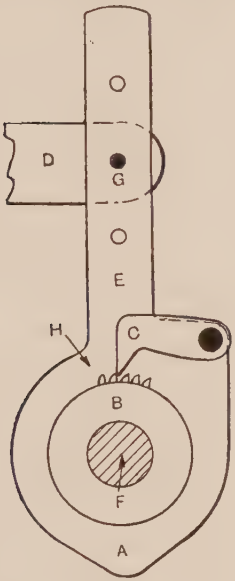


Fig. 58.

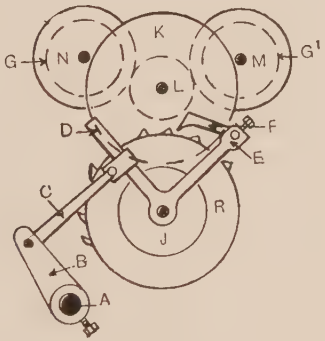


Fig. 59.

lever E, and this is the connection usually recommended. If it is required to feed a shorter length of very thick lap fringe, then the peg may be changed to the highest hole. If it be desired to feed a longer length of lighter lap sheet per nip, then the link connection may be transferred to the lowest hole. It must be noted that it is necessary to alter each roller separately; but it is an easy operation, with small chance of getting wrong.

The central hole represents 5 teeth of feed per nip.
" highest " " 4 " " " "
" lowest " " 6 " " " "

It is better to work with a heavy lap and light feed, rather than with a light lap and heavy feed, in most cases.

Closely allied to the work and adjustment of the feed roller ratchet are the work and adjustment of the lap roller ratchet wheel, the connections and parts of which are shown in Fig. 59. The finger B is set-screwed to the long nipper shaft A, and partakes therefore of the reciprocating movement of this long shaft. A two-armed cranked lever DE is connected by the arm C to the finger B. Arm E carries loosely the ratchet catch F, which gears with the ratchet wheel in the manner indicated in Fig. 59.

When the feed roller ratchet turns 5 teeth per nip, then this lap roller ratchet must also turn 5 teeth, plus possibly $\frac{1}{4}$ or $\frac{1}{2}$ a tooth to make a certainty of a properly full movement. The link C may readily be altered in its connection to D to give the extent of lap roller turning required. Wheel J is compounded with the ratchet wheel R, and by the wheels J, K, L, M, N, the lap rollers G and G′. Cases have been known in which the alteration of the lap roller ratchet R has been forgotten when feed roller ratchet has been altered, but such neglect will lead to the lap sheet being either too slack or else too tight between the lap rollers and feed rollers.

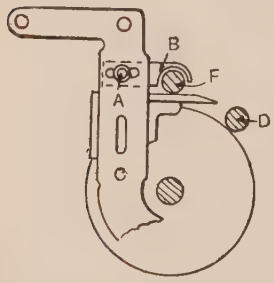


Fig. 60.

Setting of Feed Roller.

The adjustment of feed roller may be better understood by reference to Fig. 60. The turn-over bearing B (one at each end of the roller) can easily be moved about in the horizontal slot at A, so as to place the feed roller F in the desired position with the ordinary construction.

Manipulation of Nasmith Comber.

For the Nasmith comber there is comparatively little required in the way of repairs, alterations, and re-setting. The clutch box for driving the four detaching rollers has rather more to do than on the Heilmann and is perhaps rather more likely to need attention. Needles of top comb and of cylinders need repair or renewal at times. Leather detaching rollers must be properly covered, varnished, and adjusted. The short steel detaching roller may get out of position. A roller lap on the Heilmann may force the nipper into the cylinder needles, but this is an evil from which the Nasmith is quite free. In regard to minor adjustments and disarrangements, which often take up a good deal of the time of a comber overlooker, there is a marked difference in favour of the Nasmith, even when

the latter is run at almost 100 nips per minute. In starting new Nasmith combers it is possible that the main crank slide may get warm if not properly attended to. The fact that the leather detaching roller in the Heilmann must actually touch the fluted cylinder segment is responsible for a considerable amount of work of one sort or another on the part of the comber overlooker.

Take, again, the difference in regard to the nippers, in which the Heilmann has a leather cushion either in the upper or lower nip, while the Nasmith works all right without any such cushion. In a large equipment an appreciable amount of work may devolve on the foreman in taking out the nippers, re-covering them with leather, and then replacing and re-setting them. Sometimes the actual reapplication of the leather cushions may be done by someone else, but more usually it devolves upon the person directly responsible for the maintenance of the combers in good working condition. Such items make the difference between a hard position and an easy one in regard to the foreman. The revolving brushes for cleaning the cylinders may possibly require more attention on the Nasmith.

Quick Speeds.—Quick speeds and big drafts in a general way are opposed to good work and good spinning. At the same time there is little doubt that the prolonged drafting and detaching action of the Nasmith comber enables it to utilise a greater draft than the Heilmann, and hence the general use of laps heavier per yard. If the Nasmith can have the combing effect of the cylinder needles of the Heilmann, or the Heilmann can have the combing effect of the Nasmith top comb due to prolonged detaching and forward movement, then either machine will be improved.

Contact of leather roller with flutes of cylinder is a decided disadvantage.

Circular Waste Brushes.—These are much the same for Nasmith or Heilmann, or the Roth aspirator can be applied to either comber.

Fig. 61 illustrates a method of setting the brush shaft so that the bristles may be set as required up to the needles of the cylinder, using a simple measurement gauge from one shaft to the other, and getting each brush in every way tenable and parallel to its own cylinder head. Doffer shafts revolve very slowly and brush shafts very quickly.

More effective cleaning action is obtained when the circular waste brushes are reciprocated longitudinally, and Fig. 61 illustrates a method of doing this. The eccentric A receives its motion from the brush shaft by means of a worm E and worm wheel F, and works in a fixed arm B. The working of the eccentric in the fixed arm B gives a sideways action to the stud C, which carries with it

the forked bracket D mounted on each side of worm E, so that the brush shaft also partakes of the lateral traverse.

The question of waste brushes and removal of waste has been latterly distinctly affected by the adoption of the device known as Roth aspirator. Like most fresh devices, this one has not always found favour with those who have tested it, and first cost has also operated against its more extensive adoption especially in the case of existing combers already fitted with ordinary doffers, to which its application involves considerable expense. New combers have favoured its application.

When the Roth aspirator is adopted, the wire-covered doffers and their combs are entirely dispensed with. The arrangement of the brushes and the comb cylinders remains the same, but the waste is removed by an air current, operating in a manner which has very much resemblance to the action of the air current and cages of a scutcher. The revolving brushes are covered in by large strong casings, which extend also to the cylinder heads. The

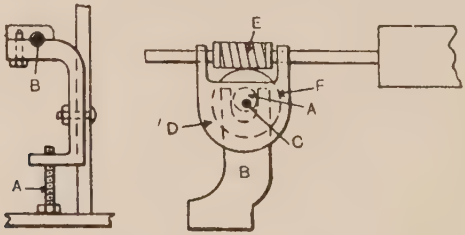


FIG. 61.

casings extend with sides to the face of a slowly revolving perforated or sieve cylinder so that the drawing effect of an air current takes the cotton waste from the brush to the face of the cage cylinder. Inside dampers allow only a limited amount of the cage apertures to be exposed to cotton, so that the waste is held against the cage by the air current until a short light roller helps to take the waste forward over the revolving cage cylinder for delivery into the usual rectangular waste boxes. The waste emerges in the form of a very thin continuous sheet, and it is claimed to be more free from nep, cleaner, and more valuable than if collected by the doffer and doffer comb.

One undoubted effect of using the Roth aspirator is that the comber is kept cleaner and more free from loose fly owing to the influence of the air current. It might be imagined that the air current would reach beyond the brush and do harm by attracting some of the good fibre and waste, but the writer has not found this defect. The air current may be induced by the rotation of a fan

at the end of the comber, driven by a small belt from a special pulley fixed on the main pulley shaft. The connecting pipe for the passage of air and dust from inside the cage cylinder to the fan may be coupled to the cage cylinder about the centre of the frame. The cage box to contain any dust and waste drawn through the dust pipe is placed partially under the gearing at the frame end.

In many combers, both Nasmith and Heilmann, the waste is rolled in muff form around a slowly revolving shaft, instead of dropping into rectangular tins.

The revolving brushes for cleaning the cylinders may possibly require more attention on the Nasmith on account of the high brush speeds, the thick lap sheets, and the high number of nips per minute sometimes obtained.

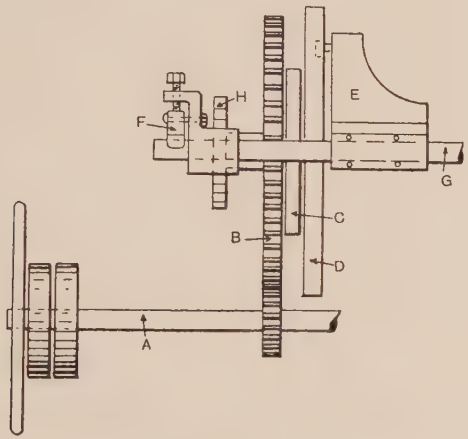


Fig. 62.

One of the advantages of the Nasmith comber is that the nipper holds cotton fibres in a straighter line than on the Heilmann. Some foremen have partially obtained this good effect by using Heilmann $\frac{3}{16}$ inch or $\frac{1}{4}$ inch stepped gauge for the nipper screws instead of a $\frac{5}{16}$ or $\frac{3}{8}$ inch, so that the lower nipper does not follow the upper one as far when nippers are opened, and the fibres are held in a somewhat straighter line up to the detaching rollers. Also it gets the practical effect of the feed rollers in a sense working as if they were set closer to the detaching rollers, and in this way it enables the detaching rollers to seize fibres of slightly shorter length, and therefore to reduce the waste per cent.

The stepped gauge is used on the Heilmann to hold the nippers

down to the cylinder needles while the nipper is being adjusted thereto. Using the thinner stepped gauge as explained above may permit a somewhat wider opening of the nippers, due to the upper nipper leaving the lower one to a greater extent.

It is perhaps not of much use setting the top comb farther away on the Nasmith, because the body of fibres is so great that the detaching rollers will sometimes scarcely master the drafting-out work unless the top comb is properly down.

The Quadrant.

Fig. 62 illustrates the parts very directly concerned with the working of the quadrant. It is a back view, showing the method of driving the eccentric for oscillating the inside leather detaching roller, the cam for moving the quadrant upwards and downwards, the index wheel, and the nipper shaft.

We need scarcely remind most of our readers that for the Heilmann combers there are two extensively used and rival methods of giving the required backwards and forwards rotary movement to the detaching rollers. The older arrangement consists of the combination of internal wheel with the large notch wheel and connected cams, while the more recent method is to combine the quadrant or section wheel with a roller box or clutch box, with suitable cams for operating same.

The latter combination has been successfully adapted to the Nasmith, and has been constructed in a strong, rigid, durable, sweet-working manner which inspires confidence in those who have to deal practically with it in the mills.

Nasmith Comber Notes.

1. The carrier wheel between steel detaching rollers must be deeply in mesh to prevent back-lash between these rollers.

2. The feed roller bracket has three holes, the top giving four teeth of feed, middle five teeth of feed, and bottom giving six teeth of feed. Care must be taken that the pawl actuating the 75's ratchet wheel must move the same number of teeth to correspond with the hole in use in feed roller bracket.

3. In general practice five teeth is usual, but for very fine work four teeth may be used.

4. To brush cylinders, lift feed roller and lap roller ratchets. It is unnecessary to break the laps.

5. After setting up for any particular class of cotton, adjustment of percentage of waste is made by altering the distance to which nipper approaches steel detaching roller. Nearer for less waste, farther away for more waste. This is done by means of setting

screws in brackets on gearing end of rocking shaft. Top comb should be set at every adjustment for waste.

Setting and Timing of Nasmith Comber.

1. *Cylinders.*—At index $2\frac{1}{2}$ set the cylinder in the middle of each head, having $2\frac{1}{2}$-inch gauge between steel detaching roller and front edge of plain segment. Secure tightly by means of set-screws which are seen by removing thin strip behind the last row of needles.

2. *Stud in Index Plate.*—Screw up this stud so that centre of same is exactly opposite index 37. Fix slide bar and secure with nut and bolt when the setting-screws are projecting equally and in contact with slide bar. During setting it is necessary that this stud be at 37, but it may afterwards be altered a little either way to obtain good piecing without altering any other setting.

3. *Cushion Plate to Steel Detaching Roller.*—At index 19 set cushion plate parallel to and at required distance from steel detaching rollers by means of step gauge. This distance may be,

8	for	combing	waste
10 to 12	,,	,,	Egyptian
up to 15	,,	,,	Sea Islands.

Screws securing nipper frames to fulcrum must be loose during this setting.

4. *Nipper Knife to Cylinder Needles.*—At index 33 adjust nipper to needles to gauge 25/1000, the nipper springs being in position.

The screws mentioned in Section 3 must be screwed up during this setting. Also the bowl for opening the closing nippers must be clear of incline bracket.

5. *Opening and Closing of Nippers.*—At index 27 set slide so that incline bracket is just in contact with nipper bowl. Then at index 19 depress the toe of incline bracket so that nipper is open to flat 12 of step gauge. As these two settings of incline bracket interfere with each other, several readjustments may be necessary to obtain exactly the bowl just in contact at 27 and the nipper opened at required distance at 19.

6. *Top Comb.*—At index 19 set top comb so that points of needles are $\frac{1}{16}$ inch from steel detaching roller and the depth of the needle points so that the gauge 6/1000 is lifted by $\frac{1}{8}$ inch above front steel detaching rollers. A medium angle of top comb is obtained by allowing top comb to project $\frac{5}{8}$ inch beyond top comb body.

7. *Top Comb.*—At index 11 set top comb lifter brackets so that top comb bowls are just in contact.

8. *Feed Rollers.*—For long cottons set feed rollers as far back as

slots will allow and parallel to steel detaching roller. Shorter cottons allowing same to be set nearer. Feed roller springs require only a light tension, as too great a puckering of the lap may take place behind the feed rollers.

9. *Detaching Rollers.*—Loosen quadrant cam and turn backwards as far as possible, then turn to index 1 to 2 according to length of staple, and move cam forward till steel detaching rollers begin to move. Test this setting by running machine by hand.

For trial setting for Egyptian cotton set at $1\frac{3}{8}$. This setting is most important and should be regulated by tests of waste in conjunction with a good piecing. If the movement of these rollers is at all too early, then a small quantity of combed fibre is taken by the cylinder during the backward motion of detaching rollers. If too late then piecing is affected.

10. *Leather-covered Detaching Rollers.*—At index 20 set eccentric so that back lifter shaft lever begins to move inwards. Generally it is better to screw stud in lever close to top of slot. Set leather-covered detaching rollers so that they are parallel with steel detaching rollers, then at index 19 adjust to about $\frac{1}{32}$ inch clear of top comb. This setting is very important, as if too much clearance is allowed, there will be needless waste.

11. *Detaching Roller Clutch.*—Set clutch so that it begins to move at 38, then loosen clutch fork pivot and turn machine to index 10. Move clutch lever stud along slot as far as it will go without forcing and secure there. Now turn to index 28 and secure, "holding segment" exactly in mesh with clutch.

Path of Cotton Fibres.—One of the important features and principles of the Nasmith comber consists in having a nearly horizontal line of fibres during the detaching operation. The effect is to bring the biting point of the detaching rollers closer to the nippers and to the bite of the feed roller than would otherwise be the case, and so to obtain the same effect that would be obtained by setting the draft rollers closer together, centre to centre. It helps to explain why it may be reasonably claimed that the Nasmith is better suited to operate upon shorter stapled cotton than the Heilmann, although it must not be overlooked that the feed roller is set back on the nipper in the Nasmith. Fig. 63 illustrates this particular feature.

Referring now to Fig. 63, it will be noticed that the feed rollers F have their biting centre much higher than the biting point of the leather roller with the fluted segment or with the long steel bottom detaching roller. On the ordinary Heilmann it does not appear feasible to get these biting points of feed and detaching sufficiently close together to work properly cotton fibre of from 1 to $1\frac{1}{8}$ inches in length, or in any way near enough to the horizontal line. By dispensing with the long bottom feed roller, and by placing the bite

of the fibres between the cushion plate E (Fig. 63), and the single feed roller F, this biting point of feed is brought into nearly the same horizontal line as the biting point of the detaching rollers at D (Fig. 63).

This is a fundamental and vital rearrangement of the central organs which affects the length of fibre it is possible to decide on passing into the good sliver, acting in conjunction with the long overlap. As a matter of fact, actual measurements and actual experience serve to show that the ordinary Heilmann can only be satisfactorily operated and adjusted to work cotton at least $1\frac{1}{4}$ inch in length, such as moderate Egyptian, fair Brazilian, or good staple American. This alleged defect, however, has not been as evident and as troublesome to the trade as some people might imagine, because it has not yet been found expedient to comb like the full

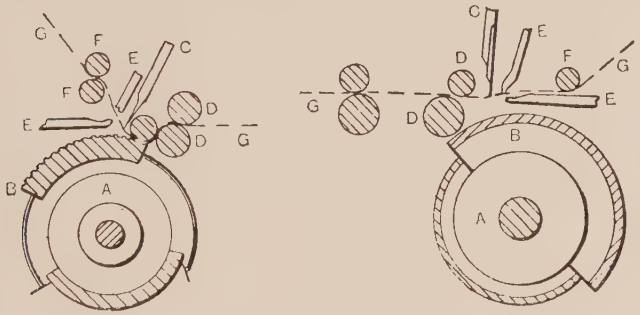


Fig. 63.

annual crop of Egyptian and South American cotton, let alone going into the distinctly shorter ordinary American cotton.

Piecing Operation.—When referring to the path of the fibres and the possible effect on the length of fibre combed, it is well to consider the piecing actions of the Heilmann and Nasmith combers. It is hardly to be disputed that the piecing action of the Nasmith comber is superior to that of the Heilmann, and that this is a great reason why it should be possible to comb shorter stapled cottons on the Nasmith comber. For good Egyptian or Sea Islands, this and other defects of the Heilmann do not show up much, and its superior features show up still better. The overlap of the Heilmann is very short, and this often gives a sliver in the collecting tin which appears uneven, choppy, and sometimes cloudy, and almost as if cut. The work of the draw box of the comber, and even the work of the first draw-frame, may be prejudiced in this way.

If the ordinary hollow-ended $1\frac{5}{16}$-inch gauge is used for setting the cushion plate of the Heilmann from the long steel detaching roller, the machine will extract fibre as waste up to $\frac{7}{8}$ inch or more in length, and all fibres projecting from the nippers at the next cylinder combing will be more than $1\frac{1}{8}$ inch in length. The corresponding setting on the Nasmith may be $1\frac{7}{16}$ inch from the inner detaching roller to the front edge of the cushion plate. A close examination of the feeding, nipping, and detaching settings and actions reveals the fact that there is little if any difference in the number of combing actions on the same fibre between the two combers, but the cylinder combing of the Heilmann is more efficient than that of the Nasmith on present constructions.

Detaching by the aid of the fluted segment on the Heilmann is a weak feature, limiting the power of increasing either the amount of backward or forward movement of the detaching rollers or varying their speeds, and therefore limiting the amount of overlap in the piecings of the sliver. Because the leather-detaching roller must get up speed before touching the segment there is a distinct loss in the amount of forward motion.

It is one of the very finest and most fundamental features of the Nasmith comber that no detaching roller touches the detaching segment of the cylinder. There is no absolute need for the two surface speeds to be exactly alike, and experience has shown that a plain segment will do instead of a fluted one. The backward motion may return $2\frac{1}{16}$ inches of fleece on the Nasmith; whereas a return of $1\frac{3}{8}$ inch on the Heilmann is sufficient sometimes to strain the fleece.

The detaching rollers in the Nasmith comber seize the fibres at their tips and do the detaching gradually, and this is one reason why the detaching action may be such a prolonged and large one as compared with the Heilmann comber, in which the leather roller drops upon the middles of many fibres. In the Nasmith comber, if the forward motion commences at $8\frac{1}{2}$ of the 40 index wheel, the fibres in the fleece may not reach the nip of the detaching rollers until about 11 of the index, and so when the tips of the fibres reach the nip of the detaching rollers the $2\frac{1}{16}$ inches has been brought down to $1\frac{1}{2}$ inch. To this $1\frac{1}{2}$ inch may be added the length left projecting from the back of the detaching rollers, which gives 2 inches of a piecing overlap.

In giving parallel order and silky appearance to the fibres, and in the cleaning power of the cylinder needles, the Nasmith is hardly up to the Heilmann, because cylinder action has apparently been sacrificed to obtain more efficient detaching and top comb actions. Undoubtedly the two latter merits are very great.

The Crank and Nipper Driving Arrangements.

The nipper of the Nasmith cannot be pushed into the cylinder needles by a roller lap because it is centred and fixed to prevent downward movement. There is no yielding cushion on either of the jaws.

On the Heilmann the nippers are operated by cams on the cam shaft—one cam near each end of shaft.

On the Nasmith the nippers are operated by a crank arrangement at gearing end; and although the crank as a mechanical power is more limited in scope than are cams of various shapes, yet it is admirably fitted to give the effects and movements desired from the Nasmith nippers.

The stud D (Fig. 64) is screwed up to the centre of the slot in the index plate G with its centre radially opposite the mark 37. The edge or rim of the index plate is marked into forty divisions, and this plate serves the double purpose of a driving crank and as an

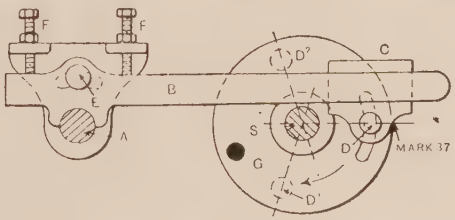


Fig. 64.

index plate. It is fixed on the cylinder shaft. The crank arm or slide bar B is bolted at E to the bracket fixed on nipper shaft A, and at the start the two setting-screws FF should project equally. The stud D may be afterwards adjusted a little in the slot of the index plate in order to get a cotton piecing suitable for kind of cotton used, and this stud position decides the time when the nipper reaches the detaching roller—an important item in making a good piecing.

Because the slide piece C is near end of crank arm for downward movement of arm and forward movement of nippers, this forward movement is advantageously slower than the backward movement of nippers. D^1 to D^2 in direction of arrow may represent lift of crank and recession of nippers.

Automatic Stop-motions.—The question of the practical value and utility of automatic stop-motions for combers has been a debatable one. Their value is greater on the Nasmith comber, with its increased production and speed and its thicker lap sheet, than

it is for the average Heilmann, with more moderate speeds and productions.

It is a common thing to find a Nasmith comber with automatic stop-motions operating upon the fulfilment of any one of three conditions; whereas it is more common to find the Heilmann working with only one of the three, although all three details of the stop-motion were applied when required to the ordinary Heilmann before the Nasmith comber began to be made.

Stop-motion at Collecting Tin or First Calenders.—Referring for a moment to draw-frames, there are chiefly two methods of obtaining the fundamental movement in the case of automatic stop-motions for draw-frames—viz. (1) by means of a revolving wing shaft or wiper shaft, and (2) by means of an oscillating bar or bars. The oscillating bar or rock shaft is the usual one adapted to and employed on a comber, the oscillation being usually obtained from an eccentric in the Heilmann, but from the nipper shaft in the Nasmith. This utilisation of the nipper shaft is a very convenient

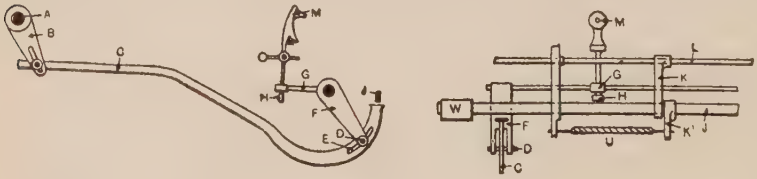


Fig. 65.

one on the Nasmith, rendered possible by the use of a rocking nipper shaft placed in a suitable position.

Fig. 65 is a simple diagram which will enable the central connections of the stop-motion to be understood, and also the special application to the collecting tin or front table, which is one of the three stopping details. Upon the long nipper shaft A at the gearing end of the comber is secured the slotted finger B, to which is adjustably pivoted the long cranked lever or bar C. The right-hand end of C is weighted to rest solidly upon a stud at D, fastened to the arm F. The latter forms part of a lever of which G constitutes the other part. At M is the trumpet or sliver part of the trumpet-lever, balanced as shown upon a knife-edge. When the comber is working and the sliver is passing properly forward, the sliver holds the upper end M of the spoon lever sufficiently forward to keep the lower end H clear from the path of the rocking arm G. Assuming a sliver to fail at this point, or even partially to fail, the lower end H of the trumpet lever enters the path of the arm G and prevents the rocking movement of the same. It should be understood that the crank lever FG is normally rocked by a simple

weighted or frictional contact of the stud D with the long arm C, so that FG can only be rocked when it will move easily, which is the case when the comber is fully working. Assuming the trumpet lever MH to be allowed to fall back owing to the absence of cotton, the crank lever FG is locked at H, as shown in Fig. 65. The effect is to prevent the long arm C from oscillating the lever FG, and consequently the right-hand end of the lever C ascends so as to lift up and unlatch the stopping bar, or rod at J. At the right hand of Fig. 65 is a front view of the automatic stop-motion, and shows that two rods are used.

The long stop-rod, marked L, extends the length of the machine, so that the operative may conveniently start and stop the comber without interfering with the automatic rod when the latter is latched against the pull of the spring. One of the best features in this particular arrangement consists in the positive manner in which the cotton sliver holds the trumpet lever forward or down.

In some instances a row of spoon levers has been fixed on the front table in front of the draw box, but this method finds few advocates.

Spoon levers act most promptly when held down by cotton slivers under a little tension. On the draw-frame this has been met by the very general adoption of the single preventer rollers. This fact requires to be borne in mind with added emphasis in connection with the comber, because of the very soft nature of the sliver due to the parallel order of the fibres. The trumpet lever of the Nasmith comber in front of each pair of table calenders fully provides for this detail.

Coiler Top Stop-motion.—The same foundation parts are utilised for all the three stop-motions, as, for example, the cranked rocking arm C in Fig. 66, the rocking arm F, and all the details shown in Fig. 66. The rocking shaft marked J in Fig. 66 extends the full length of the frame to the coiler end or draw box.

Referring now to Fig. 66, the long rocking shaft J, by means of the arm H and the connecting rod G, imparts a rocking motion to the crank lever EF. The upright link rod D conveys this rocking action to a lever BC placed nearly at the coiler top. The upper or spoon end A of the spoon lever extends a little above the highest point of the coiler, so that the sliver in passing to the coiler top rollers pulls in a downward and slightly forward direction upon the spoon top. When the sliver is passing properly into the can, the end of arm B of lever BC oscillates just clear of the lower end of the spoon lever. If there be a roller lap in the draw box, or if the cotton breaks after leaving the draw box, or fails to come forward from any cause, then the lower end of the spoon lever A enters the path of the lever BC, and prevents this latter from rocking. Exactly the same result follows as in the case of the

trumpet levers of the collecting tins, and as illustrated in Fig. 65; the spring rod is unlatched, and at once slides the long stop-rod so as to place the driving belt upon the loose pulley.

An examination of the position and detailed construction of this extension of the stop-motion principle shows it to be built upon well-considered and mechanically sound lines. There are comber overlookers who would use a stop-motion on the comber in this particular position and not in any other, nor for any other purpose. There are others who object to the motion first described because the tenter has to hold the rod on or the trumpet forward after piecing a broken sliver. There are very many who contend that automatic stop-motions of any kind and in any position are not worth having for the ordinary Heilmann, holding the opinion that competent and careful tenters will do all that is necessary, and stop-motions are only so much delicate mechanism which want attention on the part of those in charge. These conditions do not apply to the Nasmith because of its greater productiveness.

Stop-Motion at Feed of Comber.

A ribbon lap machine is usually fitted with an automatic stop-motion operating between the lap rollers and back draft rollers.

Properly adjusted, this back stop-motion does good work on the ribbon lapper, partly because of the rapid manner in which the back lap unwind.

In this note we desire to point out that similar devices have been applied to the back or feed part of a comber, but with a much less amount of practical adoption because of the intermittent and very slow unwinding of the laps. Applied to the back sliver tins between the wood lap rollers and steel feed rollers.

In many Heilmann combers all the three sections of automatic stop-motion ((1) full can, (2) between draw box and coiler top, (3) at each pair of table calenders) have been taken off on the plea that the trouble of keeping them in good order was more trouble than the benefits were worth.

A comber full can motion does not stop a tenter from changing a can before it is quite full, although it may help a foreman to check the workings.

A full can motion for the Nasmith is illustrated in Fig. 66. This motion is actuated from the table calender roller shaft S by means of a worm Y and worm wheel Z, to which is fastened the small adjusting levers X and X′ (see right hand part of Fig. 66).

Connected to these is the pawl R which gives motion to the ratchet wheel N, to which is fastened the stud T. On the same stud as the ratchet wheel, and working loose on the same is a catch P, which, as the ratchet wheel revolves, is carried round by the

stud T till it comes into contact with the knocking-off lever J, which it lifts up and releases.

Then, by means of the spring U and brackets K and K′ the setting-on rod S moves the driving strap on to the loose pulley and stops the machine.

Driving of Detaching Rollers.—The driving of the detaching rollers is anything but a simple, straightforward arrangement, either on the Heilmann or the Nasmith combers. The peculiar actions required from the detaching rollers make it almost impossible to obtain such actions in a satisfactory manner excepting by means of cams and eccentrics. All the three detaching rollers of the Heilmann comber and all of the four detaching rollers of the Nasmith comber need to have rotary movement. This rotary movement must be intermittent, the rollers having to rotate through a portion only of the comber's cycle of movements, whether it be in the

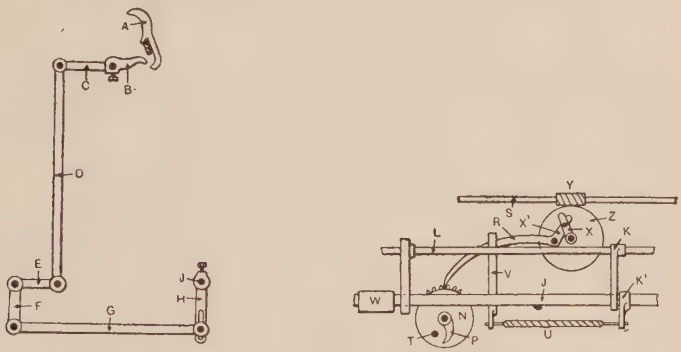


Fig. 66.

Heilmann or the Nasmith cotton comber. Moreover, the rotation must be in one direction for delivery of the combed cotton, and in the reverse direction for piecing-up purposes. Added to all this, it is necessary for the delivery of cotton each time to equal approximately double the amount of the return. A consideration of these factors enables us to realise the necessity for using a cam as a basis for obtaining the proper rotary motion of the detaching rollers; and yet this only comprises one-half of their total movement, and we have also to consider their movement through space. In the Heilmann comber two of the three detaching rollers are moved through a space of about $\frac{3}{8}$ inch every complete nip; while in the Nasmith the inner one of the two top detaching rollers is moved bodily through a space of about 1 inch.

This bodily movement is, of course, an equal distance backwards and forwards, but there is a slight pause before the roller begins to

reverse, and it must be noted that the amount and character of pause make it difficult to obtain the movement except by means of a cam or eccentric. The detaching rollers have a reciprocating, oscillating, rotary, and intermittent movement. They operate in conjunction with the cylinder in properly detaching and delivering the combed cotton. The rolling action of the inner top detaching roller of the Nasmith comber controls to a great extent the length or fringe of cotton treated by the detaching rollers, acting in conjunction with the moving nippers.

At about index 11 of the 40 index wheel the teeth of the top comb may be about $\frac{13}{16}$ inch away from the nip of the detaching roller.

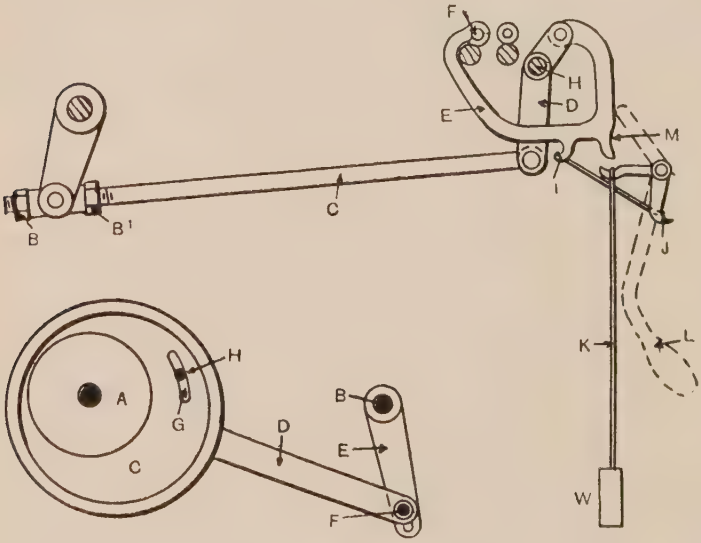


FIG. 67.

From No. 11 to about 19 the inner detaching roller rolls bodily away from the moving top comb for a distance of about $\frac{9}{16}$ inch at the nipping point, in addition to a nice amount moved by the top comb itself, giving more than 1 inch bodily movement of the leather roller as compared with possibly $\frac{3}{8}$ inch bodily movement of the leather roller on the Heilmann. The rolling action of the inner leather roller on the Nasmith comber helps in the drawing out or reduction in density of the lap fringe, owing partially to the increased speed of the detaching roller over the moving nipper.

The Eccentric Motion.—The mechanism of the Nasmith comber which is directly concerned in imparting the rolling movement to

the leather detaching roller is illustrated in Fig. 67, two views. It may be here noted that the various mechanisms for giving intermittent and reciprocating movement to the central organs of the Nasmith comber are all directly centred on the cylinder shaft at the headstock or gearing end of the comber, and include the following details :—

1. Index wheel or crank motion for operating the nippers and top combs.
2. Large cam for operating the quadrant.
3. Small cam for working the clutch box.
4. Eccentric for imparting bodily movement to the inner top detaching roller.

The eccentric of No. 4 is marked C in Fig. 67, and is fixed on the cylinder shaft A, and by its rotation it oscillates the rocking arm or eccentric arm D. By the stud at F and the arm E the required rocking movement is imparted to the rocking shaft B. This shaft extends nearly the length of the frame, parallel to the long nipper shaft, and has fitted on it two of the arrangements shown in Fig. 67, one towards the outside head of each end of the comber.

Rotary Motion of the Detaching Rollers.—While only one of the four detaching rollers of the Nasmith comber has bodily movement, all four must have rotary movement, and it is not permissible to have any material difference between the surface speeds of any of the four. It would perhaps be a good thing to have a roller draft between the inner and outer pairs of detaching rollers, but the reversing or piecing-up revolution of the rollers complicates this problem, since a drawing out of the cotton during delivery would mean a corresponding slackening during the reverse action, unless means were adopted for preventing this effect.

Many difficulties accompanied the first trials of the comber quadrant, which are seldom found now, even on the Heilmann, owing to improvements. The fulcrum of the quadrant on the Nasmith comber is centred on the nipper shaft, so that this stout, long shaft acts as a stud for the quadrant, which works loosely thereon, a very wide bearing being obtained, and no possibility of the quadrant teeth in any way twisting or locking across those of the driven wheel.

The bowl which connects the quadrant arm with the large cam groove is near the middle of the single quadrant arm that is used, and the net result is a smooth powerful drive that impresses one with its certainty of action and promise of durability. Moreover, it is easy to take out and replace whenever required.

Driving of Lap Rollers.—Fig. 68 illustrates one of the minor details of the gearing of the Nasmith comber—i.e. the special arrangement for driving the wood lap rollers. A side view has been given previously. This is entirely different from the equivalent

mechanism on the Heilmann, and although apparently effective, the present writer prefers the Heilmann arrangement. On the Heilmann there are simply two pairs of small bevels, and a short side shaft connecting the steel feed rollers with the wood lap rollers, and whenever any changes are made in the amount of feed per nip or in the time of feeding, equal effects are obtained on both steel and wood feed rollers. The independent driving of wood feed rollers for the Nasmith, as illustrated in Fig. 59, prevents any such guarantee, and separate alterations are necessary to maintain the best effects.

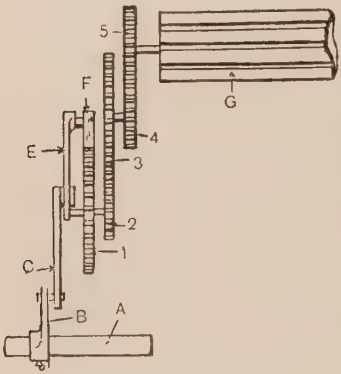


FIG. 68.

In Fig. 68 the finger B is adjustably set-screwed to the long nipper shaft at the gearing end. The oscillation of the nipper shaft is conveyed by finger B and levers C, E to the ratchet catch F, which is moved backwards and forwards and imparts the required forward movement to ratchet wheel No. 1. A small brake arrangement presses against the ratchet wheel 1 to prevent overrunning. Small wheels 2 and 4 drive large wheels 3 and 5, there being a wheel No. 5 for each of the fluted wood lap rollers. The large diameter of the wood feed roller, as compared with the steel feed roller, compels the use of small wheels driving large ones in order to reduce the speed ratio to the right dimensions.

CHAPTER VI.

FLY-FRAMES.

Defects in Bobbins and Rovings: Running Under and Over.

One of the most frequent defects is running under or over the ends of the bobbins. There are many causes for this, such as the cone belt being overloaded at the reversing point of lifter, by such items as lifter binding in the vertical racks, binding of spindles against the collars, short rack or hanger bar binding.

Run-off bobbins may also be caused by some of the wheels which connect the reversing bevels to the vertical lifter racks being loose in the set-screw or key-way; or by some of these wheels being too shallow geared.

For the excellent purpose of getting more length of cotton on a full bobbin, the amount of taper or cone in the bobbin is sometimes reduced until there is distinct danger of frequent run-off coils.

Any good tenter avoids stopping a frame just at the reversing point because this factor often causes run under or over bobbins.

If a vertical lifter rack or its pinion works loose or otherwise goes wrong it is perhaps best to wait until doffing time before finally refixing or there will be a likelihood of coils run under or over. A frame ought to be able to run a set out without one vertical rack.

Sometimes the small driving strike bevel gets worn in the teeth, or loose in position due to the constant striking action.

An unlevel bobbin rail is conducive to running under and over. Breaking or wearing thin of the cross-pin in flyer top may cause running under or over, owing to allowing the flyer to rise on the one hand or settle down too much on the other hand. Setting skew bevels too deep in gear and bobbins not properly fitting on the bevels will cause running under.

The horizontal catches or pigeon levers of the change motion require a good tensioned spring to draw them promptly into gear, and the vertical catches of the ratchet wheel require to act efficiently to prevent running-off coils.

Soft Bobbins.—Odd ends slack and odd bobbins soft, are often caused by a tenter allowing ends to remain down a short time, or by removing a fair amount of "thick" or "single" roving from a

bobbin. Such bobbins wind slack and soft for a time and to make them appear to work all right a tenter may wrap the cotton only once round the paddle instead of three times. By holding a finger against the front top roller a tenter may get a slack end to take up.

Some managers would rather see a spindle stopped until doffing time than have a soft bobbin made in this way, or the equally bad effect of a spare bobbin of rather larger diameter being put on.

Operatives.

There is no better guarantee for obtaining quality, quantity, and freedom from breakdown on fly-frames than having a good supply of well-trained, skilful, and careful operatives, who value their jobs sufficiently to wish to retain them. Not only is their own work satisfactory but they lay a good foundation for the work of the mules or ring-frames.

Boarding down the alley ways 3 or 4 inches deep is often a great help to short tenters on intermediates.

Paddle Weight.

In a specific case no finer than 16 hank could be made. Eighteen hank was required, but the paddles would not stop to the bobbins, and the bobbins built up soft and ugly in top of set. Finally the flyers were re-fitted with new wire legs and paddles, the snug on upper portion of each flyer was done away with, the top of wire leg was hooked into a hole in the flyer leg. The wire legs were slightly heavier, the paddles held to the bobbins, and it became quite easy to get good 18-hank rovings.

Frequent Defects. Summary.

The chief are: Coils run over or under, single rovings, thick rovings, bad ends or slubs, uneven rovings, soft rovings, hard rovings due to such things as front roller slip, stretch rovings, overtwisted rovings, dirty rovings containing very small portions of nep, leaf or sand, oily or stained rovings, coils too open or too close on the bobbins.

Rough apertures in the back traverse guides, or rough places in the flyers or paddles, careless picking of flyers, bad back bobbins, dirty rollers, are all causes of defective rovings.

Faulty action of differential motion, slip of cone belt, binding of vertical racks or of lateral traverse of cone belt, wrong sizes of lifter and star wheels, bobbin ratch, variable wrapping of cotton round flyer top or round the paddle, unclean or unoiled draft rollers, uneven back bobbins, inferior cotton, blending of too widely differing kinds of cotton, neglect of proper wrapping at draw-frame,

injudicious alteration of change wheels, or neglect to alter same when required.

These are all causes of uneven work from fly-frames.

If a bobbin once begins to build up soft, spongy, and fuller in diameter, the evil multiplies on itself owing to "bobbin ratch."

Atmospheric influences—heat, moisture, electrical—all affect softly built bobbins more than firmly built ones, and this is a great merit of three times round presser. Soft bobbins are more likely to receive damage in transferring from one machine to another.

Coils Per Inch.

Although for the first layer on bobbin it is good practice to check the coiling and the lifter wheel, by taking care to just be able to detect the bare wood only between the coils, it is good practice for a carder to have a list of coils per inch of lift, which have been found suitable to the average mill conditions, for different hanks and machines. Using a better and finer cotton fibre, combing the cotton, and increased twist per inch will give a thinner roving and therefore more open spacing, with other conditions on the frame equal. Merely as a memory basis it may be assumed that the square root of the hank × 7 for the slubber, $8\frac{1}{2}$ on the intermediate, and $10\frac{1}{2}$ on the roving frame, will give somewhere near the coils per vertical inch under normal conditions, but there is no fast law in this matter.

Flyers without Pressers.—Still a few in use but number diminishing. The flyer leg is too far away to properly control and guide the cotton on the bobbin, and if one coil gets on another sometimes a ridge of coils is formed before a proper coiling gets going again.

Ridgy Bobbins.—Coils unskilfully disposed, binding of lifter, shallow and slipping gear of some one of the lifter wheels, teeth broken out of one of these wheels, irregular action of cone belt, these are possible causes of ridgy bobbins.

The Cone end wheel affects both the tension of winding and spacing of coils; and there is one wheel nearer the differential, and another wheel nearer the lifter, for separate regulation.

Defects Due to Rollers on Roving Frames.

There is no doubt that defective rollers cause a great deal of bad work on roving frames in many cases. As regards the leather rollers the principal evils are flutes, channels, nicked or cracked places, and slack leathers. Channels are circular grooves in the rollers, while flutes are grooves lengthwise, the former being often due to defective roller traverse motions, hard twisted cotton or rollers set too closely, while flutes are reproduced in the leathers

by the flutes in the iron rollers. Defective leather, unskilful roller covering, and oversharp iron flutes are causes of flutes in leather rollers, and doubtless fluting of leathers would be more general if it were not for the flutes in the iron rollers being cut eccentrically and the leather rollers made of different diameters from the iron ones.

Apart from the question of the coverings of the top rollers, there are many ways in which rollers may be out of order, or not adjusted to the best advantage. For example, the rollers may have their centres too wide apart or too close together; the weights may be too heavy or too light, or may be not acting properly on the top rollers. Much bad work is caused by heavy working of some of the leather rollers due to neglect of oiling and cleaning, or wearing of the middles. It has always to be remembered that all of the cotton goes through the rollers, and that the rollers always do the drawing out of the cotton on fly-frames.

Thick, Thin, and Stretched Rovings.

In the case of certain bobbins having thick and thin places there are perhaps two chief causes of such faults, namely, defective rollers, and what are termed "thick" and "single." Thick and thin places may be caused by top rollers being dirty and dry, especially the front row, or defectively working owing to bad leather coverings, wrong spacings, or weights out of position. "Single" may be caused by one back bobbin being broken so that only one of the usual two is going through to the front. "Thick" is the opposite effect in which a front roving is not only failing to pass down to its own spindle, but is passing along with the ordinary thickness of cotton upon an adjacent bobbin. Thick and single are of different degrees according to the frame at which the defect originates. Lumps at certain points in the roving are usually in the nature of bad ends caused by accumulations of fibre upon rollers, clearers, hooks, traverses, or flyers at times passing along with the ordinary roving upon the bobbin. After the bobbins have worked a bit stretching of rovings is very often due to using a star wheel or ratchet wheel with too many teeth in, so the cone belt does not traverse laterally quick enough. If, however, the evil is greatest in the first few layers it may be the winding wheel is wrong, and is overwinding the cotton. Occasionally the evil may be due to wrong outlines of the cone drums. About 1897 the present author issued an extensive treatise on fly-frames, at present out of print.

Thick and Thin Places in Roving.

Thick and thin places are of varied degree and character, the most extreme examples consisting of "single," due to tenters

allowing one end to go forward where there should be two. "Thick" technically means rovings in which an extra end has run in for a time at one machine or another. Such uneven work is definite in character, and usually extends uniformly over a good length of cotton yarn. Thick and thin places of an entirely different and shorter character may be due to the roller gearing being badly set, or to rollers being defectively weighted, drafted, adjusted, cleaned, oiled, or covered. Sometimes uneven work is due to the star wheel being too large, and causing the ends to overwind and ratch, the same defect being possible also through too large a winding wheel for driving the sun wheel. In every case of uneven work the cotton fed to the machine should be examined.

(*a*) Soft but uniform rovings will probably be due to insufficient twist being put in the cotton, or may arise from the raw cotton being of poor and irregular quality. Ratched rovings are both soft and variable. Soft bobbins represent another kind of defect.

(*b*) When fly-frame bobbins are unequal in top and bottom tapers, the most fruitful cause is the "taper bar," or "hanger bar," or "diminishing rod" not being exactly horizontal when the eye of the presser is in the centre of the length of bobbin. It is possible that binding and loading of the lifter at one end may have an effect on the taper of bobbin.

Particulars and Comments.—Counts spinning 32's twist; card sliver ·12 hank; 6 ends up at drawing frame, draft 6; slubbing frame draft 2; intermediate draft 6; roving draft 8. Counts spinning 60's; card sliver ·16; 8 ends up at draw-frame, draft 7·9; slubbing draft 4; intermediate draft 5; roving draft 7?

Dealing first with the 32's twist from American cotton, single roving, at the ring-frame or mule, the card sliver of ·12 is rather coarse, and probably ·14 would do better. Six ends up and 6 draft at draw-frame would work satisfactorily, and represent average practice. The slubbing draft of two is unsuitable, 4 being more likely; the intermediate draft of 6 would be high, and about 4·7 would certainly be better; while 8 of a draft at the roving-frame is much too high for 32's single roving, about 5·5 to 6 being more likely. Dealing now with the 60's, with double roving at the mule, the card sliver of ·16 is again rather on the coarse side, about ·20 or ·21 being more suitable for good work. Eight ends up at the draw-frame, with 7·9 total draft, would suit nicely. For finer counts and double roving drafts must be higher, and good practice would be represented by the following, which only differ to a moderate extent from those stated in question: Slubber 4·8, intermediate 5½, roving 7.

Bobbin Driving.—Take the ordinary Holdsworth motion. This consists of the sun wheel and four equal bevel wheels, all geared

together to form a square on the main pulley shaft of the frame. The two cross bevels have their bearings in the arms of the sun wheel, and are carried round thereby, one being simply a balance wheel. One of the four bevels is fast to the shaft, and is the main driving wheel of the motion. Assuming the sun wheel to be stopped, and shaft making 300 r.p.m. with bobbin to lead, then the bobbin wheel or driver bevel of the motion would make 300 revolutions in the opposite direction to the shaft. Assuming now that the sun wheel is also started, and makes 10 r.p.m., then the bobbin wheel would make $300 + 10 \times 2 = 320$ revolutions. The excess revolutions are obtained entirely from the sun wheel, which is driven from the bottom cone drum, and the excess is sufficient to wind the cotton on the bobbins as delivered by the rollers. If the cone belt were to slip the ends would run proportionately slack, since some of the necessary excess revolutions of sun wheel and bobbins would be lost. If the cone belt were too narrow it would not move along the cones at each change of lifter with sufficient promptness and exactness, and would tend to give some amount of uneven tension to the cotton ends, the same effect being produced by failure of the belt to maintain one position during one complete lift. There would also be a slight tendency for the ends to run under at changing of lifter with both defects specified, due to loss in winding and lifting at the change, without loss of delivery.

Creeling.—In some cases considerable trouble has been caused by careless and unskilful creeling at the fly-frame.

If bobbins are taken from the creel too soon there is extra waste and the trouble of cleaning the cotton from the bobbins. It is very bad to allow bobbins to run quite empty and thus cause single and bad piecings.

It is vastly important that tenters should take bobbins out at the correct moment, make short and only just sufficiently firm piecings, and allow no single. A two-inch overlap piecing at the intermediate may pull into 10 inches at the roving, and into 70 to 100 inches of slightly thick yarn at the mule or ring-frame. Putting two ends up together greatly diminishes the evil when done purposely on the double roving system.

When too many bobbins want re-creeling at one time it often requires a smart tenter to avoid waste and bad work. Re-creeling about one-third of a frame at one time on a definite system may help to get better results. Skewers and skewer holes should be in good condition, neither over-running nor being so hard to turn as to strain or break the cotton.

Working a full and a half bobbin together, or a front row bobbin working with a back row bobbin from the previous frame help to give good results if tenters can be got to do it, and are helped by using one colour of empty bobbin for front, and a dif-

ferent colour for back row. Bobbins should not be so full as to touch each other. Well pointed creel skewers help to keep the minimum twist in the cotton, and minimum twist means maximum production if the conditions will work. Wet, dirty, long, lumpy piecings are to be avoided.

Oil Stains.

At one time or another an enormous amount of stained roving has been made by using cracked or cut bobbins. Especially is this true when there is reckless use of quick-running oil cans in oiling the bobbin wheels and spindle collars. This oiling defect is conspicuous by affecting the first one or two layers of roving. The surplus oil gets on the inside of the bobbin and works through to the roving along which it automatically spreads.

Shorter lengths of oil stains may result from reckless oiling of rollers, or oil on guide rods for the cotton from creel to rollers. Frequently this oily roving is drafted out to long lengths at the mule or ring-frame, and allowed to pass forward into the cloth, showing up there in distinct portions of light, wavy, discoloration. Oil stains are very troublesome to the bleaching process and are difficult to remove, either in yarn or cloth.

Defective Drafting.—Badly set draft wheels, using cast instead of cut wheels, draft wheels too coarse in pitch, broad carrier not gearing accurately with either the back or the middle roller pinion, wrongly centred rollers, fluted or channelled top rollers, ineffective or wrongly working traverse motions, top rollers requiring varnishing, cleaning, oiling, and re-covering, worn roller bearings for either top or bottom rollers, slackness in the bottom roller "squares," mixing of long and short fibres of cotton, excessive twist in the creel bobbins, wrongly weighted top rollers or weights out of position, weight hooks binding on top rollers, excessive or insufficient drag from creel to rollers, moisture in cotton, dirty or rough holes in the back guides, strained bottom rollers. These are all possible causes of drafting defects.

Uneven Rovings.

Whether these are caused by binding rollers, uneven diameters of empty bobbins, tenters winding back the cone belt to get tighter winding, running the frame after it is ready for doffing because it is near stopping time, using bad cotton or unlevel back bobbins; the length of defective yarn is always much greater than the length of defective roving.

Working back from the yarn we should divide by the draft, and working forward to the yarn we should multiply by the draft, in order to trace a cause or remedy.

Speeds and Twist.

With Egyptian cotton it has repeatedly happened that twist could be taken out so as to speed up the rollers, and larger frame pulleys put on to reduce the whole speed of the frame, with the net result of easier work for tenter, less noise, less wear and tear of parts, increased production, and better quality.

With American cotton it has repeatedly happened that frames have been decidedly reduced in speed and better results obtained

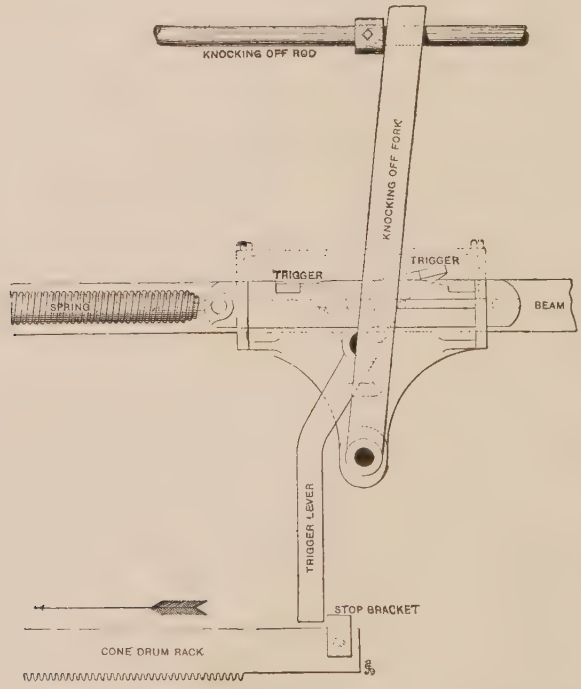


FIG. 69.—Full bobbin stop-motion (Brooks & Doxey).

in every way. It is impossible to piece up on a fly-frame without stopping the machine, and therefore anything that reduces the number of broken threads helps to increase production in more ways than one.

To ascertain the twist per inch a ready practical method is to turn the frame by hand, carefully count the exact revolutions of spindle for one of front roller, and then divide these spindle revolutions by the circumference of front roller.

When the frame is stopped by the motion shown in Fig. 69, the cone belt needs winding back before re-starting.

Cone Drum Calculation.[1]

The cones, as used in a slubbing frame, are 7 inches diameter at the large ends, and $3\frac{1}{2}$ inches at the small ends; the bobbin is $1\frac{1}{2}$-inch diameter when empty, and 6 inches diameter when full. Assuming the whole length of the cones (which is 36 inches) is used to build a full bobbin, what diameters of the cones should the belt be on when the bobbins are $3\frac{1}{2}$ inches diameter?

Method I.

For convenience in working we will assume the top cone drum to have the fixed speed of 100 r.p.m., although in actual practice it revolves more quickly than this.

(*a*) $\frac{7 \times 100}{3\frac{1}{2}} = 200$ r.p.m. for bottom cone for $1\frac{1}{2}$ inch empty bobbin.

(*b*) Assuming the initial revolutions of bottom cone to be 200, these revolutions will be reduced in proportion to the increase in bobbin diameter. Therefore

$\frac{200 \times 1\frac{1}{2}}{3\frac{1}{2}} = 85{\cdot}71$ r.p.m. of bottom cone for $3\frac{1}{2}$ inches diameter of bobbin.

(*c*) $100 + 85{\cdot}7 = 185{\cdot}71$ = sum of the revolutions of the two cones for $3\frac{1}{2}$ inches bobbin.

(*d*) $185{\cdot}71 : 10{\cdot}5 :: 100 : ?$

$\frac{10{\cdot}5 \times 100}{185{\cdot}71} = 5{\cdot}65$ inches diameter of bottom cone for $3\frac{1}{2}$ inches bobbin, so that diameter of top cone $= 10{\cdot}5 - 5{\cdot}65 = 4{\cdot}85$ inches.

Method II.

It is sometimes contended that for strict accuracy in such a calculation the thickness of the cone belt should be considered.

To demonstrate the exact effect of such a detail we will go through the same calculation, but taking the cone diameter to the centre of a thick cone belt—say, $\frac{1}{4}$ inch thick—so that we take initial working diameters at $7\frac{1}{8}$ inches and $3\frac{5}{8}$ inches.

1. $\frac{7\frac{1}{8} \times 100}{3\frac{5}{8}} = 196{\cdot}5$ initial revolutions of bottom cone.

[1] See also p. 270.

2. $\frac{196{\cdot}5 \times 1{\cdot}5}{3{\cdot}5} = 84{\cdot}2$ revolutions of bottom cone required for a $3\frac{1}{2}$ inch bobbin.

3. $100 \times 84{\cdot}2 = 184{\cdot}2$ = sum of revolutions for $3\frac{1}{2}$ inch bobbin. Sum of dias.

4. $\frac{10{\cdot}75 \times 100}{184{\cdot}2} = 5{\cdot}84$ diameter of bottom cone plus $\frac{1}{8}$ inch for belt for $3\frac{1}{2}$ inches bobbin.

5. $10{\cdot}75 - 5{\cdot}84$ = diameter of top cone at same time = 4·91.

Subtracting the $\frac{1}{8}$ inch for working to centre of belt from each of these answers, we obtain the following results :—

5·715 inches diameter of bottom obtained by the fuller method.
5·65 inches diameter of bottom obtained by first method.
4·785 inches diameter of top cone obtained by second method.
4·85 inches diameter of top cone obtained by first method.

Fly-Frame Calculation.

If a roving frame has a spindle speed of 1,100 r.p.m., how many revolutions would the front roller, which is $1\frac{1}{4}$ inch diameter, make when producing four-hank rovings? What change would you make for a six-hank roving?

Areas of similar yarns or rovings vary substantially in inverse ratio to the counts, but diameters of such yarns vary inversely as the square roots of the counts, which is a very different thing. Experience long since demonstrated that to produce similar twist effects in cotton yarns and rovings the twist must vary with the diameters, and not with the areas or counts of yarns, and this is just the reason why square roots of counts are obtained in altering twist and speed wheels, and therefore why twist varies with the square roots of counts.

Second part :—

$\frac{5 \times 22}{4 \times 7} = \frac{110}{28} = 3{\cdot}928$ inches circumference of front roller.

We will assume the twist constant to equal 1·15, i.e. twist per inch = $\sqrt{}$ counts × 1·15.

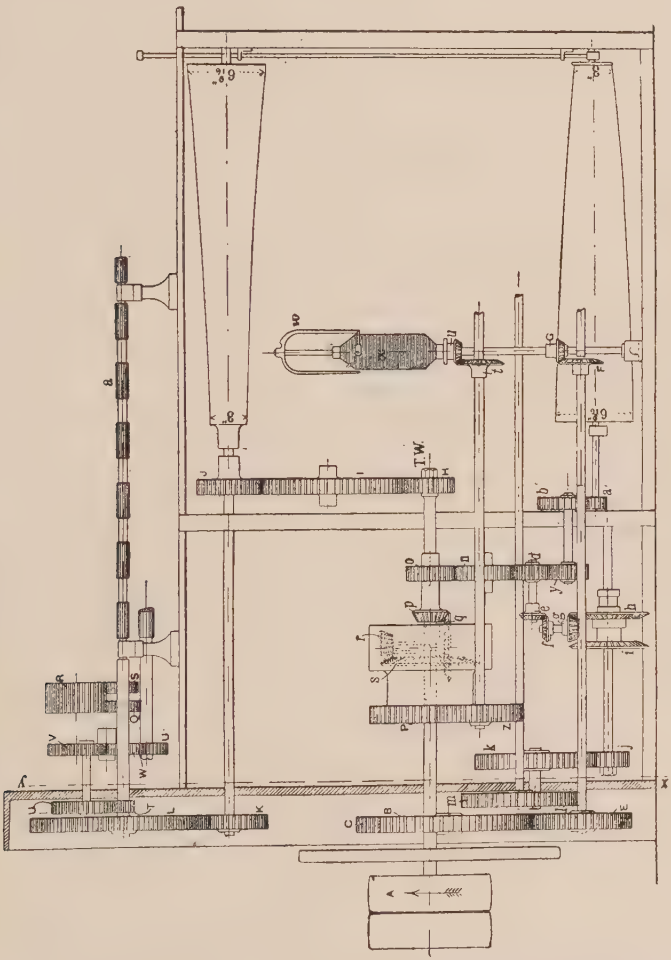
$\therefore \sqrt{4} \times 1{\cdot}15 = 2 \times 1{\cdot}15 = 2{\cdot}3$ turns per inch.
$1100 \div 2{\cdot}3 = 478{\cdot}26$ inches del. from front roller.

Answer.—$478{\cdot}26 \div 3{\cdot}928 = 121{\cdot}72$ r.p.m. of front roller.

The adoption of a different twist multiplier would, of course, lead to a somewhat different answer.

Twist Wheel Calculation.

What twist wheel will be required to give five turns of spindles for one of front roller? Driving wheel 54 teeth, outside spindle shaft wheel 54 teeth, skew gear wheel 50 teeth, skew gear wheel on



"SPEED" FRAMES.

FIG. 70.—(Messrs. Howard & Bullough.)

spindle 26 teeth, top cone drum inside wheel 30 teeth, top cone drum outside wheel 40 teeth, front roller wheel 115 teeth.

In order to make this answer clear we will first state the calculation as a simple speed problem, regarding the front roller as the

driver, and making one revolution, from which we require to find the revolutions of spindle in same time. Thus—

$$\frac{1 \times 115 \times 30 \times 54 \times 50}{40 \times \text{T.W.} \times 54 \times 26} = 5 \text{ revolutions of spindle.}$$

If the twist wheel were given and revolutions of spindle not given the above would have been method of stating the problem. From this it needs but a very moderate amount of reasoning and arithmetical knowledge to show us that we may substitute the five revolutions of spindle in place of the twist wheel, from which to obtain the required twist wheel. Thus—

$$\frac{1 \times 115 \times 30 \times 54 \times 50}{40 \times 5 \times 54 \times 26} = \frac{23 \times 3 \times 50}{4 \times 26} = 33\text{'s twist wheel.}$$

Possible Breakages on Roving Frames.

(*a*) One of the catches in ratchet wheel of change motion broken, (*b*) several teeth broken in bevel pinion which drives the large bevels in strike motion, (*c*) a bobbin having rolled underneath the lifter racks.

(*a*) There are two important pairs of catches or detent levers in the ordinary change motion of a bobbin and fly-frame, viz. the pair for holding the bottom cradle lever in position, and the pair for holding the ratchet wheel as per this discussion. If one of the latter were broken it would fail to hold the ratchet wheel in its own turn and the ratchet wheel would work irregularly, frequently moving a full tooth on one change of the lifter, and none at all at the other change. When the full tooth change was made the ends would slacken, and the lifter would be reduced overmuch in speed and there would be a distinct tendency for running under. The ends would be tighter at the next reversal of the lifter.

(*b*) Teeth are often broken more or less out of the small driving strike bevel, a carder student of the writer's once saying this wheel was "a little terror" for breaking. Just in proportion to number of teeth broken out together, the lifter would hesitate in its traverse every time the broken teeth came round thus giving ridgy bobbins and running off at the coned ends.

(*c*) It has happened that a bobbin has rolled beneath the lower end of one of the vertical racks, and the bobbin is generally broken. These racks in the lowest position of the lifter often come somewhat near the floor, and this permits the possibility of such an accident. In such an event it is possible for the cone drum belt to slip if very slack, thus running the ends slack; or one of the lifter train of wheels may break or slip, and permit lumps to wind round the bobbins. The particular rack concerned may break on that particular pinion.

Cones of Bobbins.—For fine rovings it is quite common to put more taper in the bobbin ends or to make longer cones, since a good length of cotton can be got on the bobbin for fine counts, even with long cones, and good work is even more necessary than for coarse rovings.

To get more cone in bobbins, a larger wheel may be used for driving the poker bar, or short rack, or else the two-bar slide may in some frames be put somewhat nearer to the change motion, and a shorter effective length of the short rack made use of.

The difference in length between the first and last layers will give the total amount of cone. If we divide this difference by twice the number of layers in a full bobbin we get the amount of shortening at each end for each layer. Number of layers on roving-frame bobbin for about nine hank may be about 100.

Flyers.—It is not a good thing to have to hammer flyers off the spindle top, and it is a still worse thing to have to hammer them down upon the spindle.

It is always a bad thing for a presser to become strained or bent out of true shape, or working in a very stiff manner. Such items tend to give breaking rovings and spongy bobbins. Bobbins and bobbin bevels should never bind on the collars or bolsters.

Cone Belts.

Cone belts should be kept tight enough to avoid slippage; but if too tight they may not respond promptly to each small change when the lifter is reversed, thus tending to stretch the rovings at the lifter reversals.

Link cone belts, made of three or four very narrow belts linked by cross-bars have been much used by some firms.

Others have done well with such belts as those in which a half-width extra belt is firmly secured to the full-width belt down the inside centre. The term "Dreadnought" has been applied to such belts.

In this way a narrow bite is obtained on the cones and yet more than the strength of a full-width belt is obtained.

Such belts need to be put on endless, but a little practice soon enables a man to thread a new endless belt round top and bottom cones, which means loosening and freeing one end of each; then re-fastening.

In some cases belts of good quality are first well broken in at the main drive of a machine and then transferred for cone belt purposes. Nothing but loss in quality and quantity of work can result from using a low quality of belting for cone drums. A good many fly-frames have had applied a system of three endless ropes $\frac{3}{8}$ or $\frac{7}{16}$ inch diameter, the forks being split into three grooves and made to

control the rope on both sides of each cone, with a method of keeping each fork equi-distant from its cone all the time. Cone belts should be kept free from fly, dirt, grease, and lumpy piecings. At start of frame an easy cone belt may tend to run down each cone, but afterwards the other way. For a short period Platts made frames containing two pairs of cone drums, using two cone belts.

Faulty Operation of Roving-Frame.

One of the most common defects is for the cotton to be run off at the ends or cones of the bobbins, and for this there are several causes, such as slippage of cone belt at the point of lifter reversal, binding of the lifter against the collars or vertical slides, or the vertical racks not being free, reversing and strike bevels being worn or shallow geared, worn bearings for lifter shaft, worn ends on the pigeon levers, insufficient amount of cone in the bobbin ends. Individual bobbins could be wound over from other causes. Stopping a frame at the point of lifter reversal may cause running off. Over-slack or over-tight winding on is a frequent evil, and may be due to wrong tenion of cones belt, wrong size of star wheel or of winding wheel put on, and occasionally it is due to a wrong configuration of the cone drums. Bad ends may be due to neglect or carelessness in cleaning the flyers, the rollers, or the traverse guides, or possibly to the use of too much short fibre in the mixing. Unlevel rovings may be caused by excessive spindle draft or bad back bobbins, while thick and single ends are due mostly to careless tenters, and thick hard ends to neglect in cleaning and oiling the rollers. Twist should be accurately adjusted to the requirements of each case. If the roller traverse motion is not well adjusted we may have running off at the ends of the rollers, or on the other hand we may have channelled top rollers. Rollers set too widely apart may lead to somewhat irregular drafting, while if set too closely may lead to "spewing" or cotton coming out in raw, undrawn pieces.

To facilitate renewal of broken spindle or bobbin skew bevels, the long thin shafts for these should have split couplings.

Spongy bobbins may be due to bad winding, but individual soft bobbins are often due to tenters pulling off some thick or "single" cotton, or allowing an end to remain down for a period, and then piecing up. By holding thumb or finger for a moment against the front roller, a tenter often gets a slack end to take up.

Variation may be due to any one of many causes, such as bad skewers, wrongly adjusted creel rods and creels, bad oiling of the slivers at the drawing-frame front cans, defective draft rollers, by damaged pressers on the flyers, stretching the sliver in lifting from the can behind the slubber.

Twist per Inch on Fly-Frames.

Wheel on front roller 180 teeth, wheel on top cone shaft, driving the front roller wheel, 60 teeth ; wheel on top cone shaft driven from the twist wheel, 50 teeth ; twist wheel, 38 teeth ; wheel on driving shaft, 65 teeth, driving through a 98 carrier to a wheel of 42 teeth ; skew gear wheel, 50 teeth, driving a wheel on spindle of 24 teeth. Diameter of front roller $1\frac{1}{4}$ inches.

Method I.—Taking the steps of the problem in detail :—

(*a*) $$\frac{1 \times 38 \times 60 \times 5 \times 22}{50 \times 180 \times 4 \times 7} = \cdot 995 \text{ inch}$$

delivered from front roller for one revolution of the pulley shaft.

(*b*) $$\frac{1 \times 65 \times 50}{42 \times 24} = 3 \cdot 21 \text{ revolutions}$$

of spindle for one of pulley shaft.

(*c*) $3 \cdot 21 \div \cdot 995 = 3 \cdot 22$ turns per inch.

Method II.—Working all in one operation :—

$$\frac{1 \times 65 \times 50 \times 50 \times 180 \times 4 \times 7}{42 \times 24 \times 1 \times 38 \times 60 \times 5 \times 22} = 3 \cdot 22$$

turns per inch as before.

The leading principle in regard to twist per inch in fly-frames usually consists in putting in as little twist as possible, so long as the cotton will wind on at the fly-frame, and unwind at the next machine without undue breakages.

There are certain standard multipliers for twist, and officials should endeavour to come somewhere near these standards, although there is no compulsion whatever so long as the work and wages are sufficiently good. The longer stapled cotton will work well with a lower twist per inch than the shorter stapled, and hence it is a general practice to work on this idea. For example, on the roving-frame the common multipliers might be about ·8 for Egyptian, 1·1 for good American, 1·2 for moderate American, and 1·35 for Indian. In each case the square root of the counts is multiplied by this constant to obtain the twist per inch required. In actual work these standards are varied according to the requirements of individual cases.

Guide Apertures and Rods for the Rovings.

There are many details connected with practical cotton spinning which are often considered too small for proper consideration by those in charge of the machines, and yet in the aggregate they often very appreciably affect the quality of the work and the number of breakages of the cotton. Under this category may be placed the

guides through which the cotton strands are made to pass on their way from creel to rollers, and also the rods round which the same strands are passed. These appurtenances are absolutely essential for the guidance of the rovings into their proper channels, and should therefore be used to the best advantage.

Take a case, for example, which entered into the writer's experience a good many years ago, and similar cases which have since been noted by him on various occasions. A good deal of trouble was caused by bad ends or small slubs coming from the intermediate frames in a card-room which was newly filled with fly-frames. Careful watching disclosed the fact that the bad ends appeared to be formed mostly between the back bobbins and the drawing rollers, and after a time the small round guide holes for the double rovings were noted to be very rough, thus causing the loosely twisted strands to be chafed so as to form small accumulations of fibre, which occasionally passed through with the rovings, and were too short to be drafted out by the rollers. After all these small round apertures were filed and rubbed quite smooth there was a manifest improvement in regard to the number of bad ends. This was clearly a case in which the machine maker was at fault, because no maker should allow considerations of price or cheap manufacture to be a reason for sending the parts in an unfinished condition in such vital items.

Cone Drum Calculation.

The cone drums of an intermediate frame are $6\frac{5}{8}$ inches and 3 inches diameter at each large and small end respectively. The empty bobbins are $1\frac{1}{4}$-inch diameter. Find the largest diameter of full bobbin which can be made on the frame, if the cone belt is allowed to traverse the full length of the cones, and flyers are wide enough.

The revolutions given to the bobbins from the cone drum connection represent the excess revolutions of the bobbin over those of the spindle. For example, if we assume the empty bobbin to make 80 more revolutions than the spindle, then it is this 80 revolutions which will be proportionately reduced, and not the total number of revolutions made by the bobbin. If the bottom cone were stopped the bobbins and spindles would make an equal number of revolutions whether it were the old sun and planet motion or any one of the new motions.

$$\frac{6\frac{5}{8}}{3}$$

represents the driving of the bottom cone drum for the empty bobbin, while

$$\frac{3}{6\frac{5}{8}}$$

represents the drive for the full bobbin. Just in proportion as the speed of bottom cone is reduced so also will the excess revolutions of bobbin be reduced, and if the size of flyers and other items permit, the winding speed will be reduced sufficiently to give a diameter of bobbin proportionately increased from $1\frac{1}{4}$ inch as the bobbin speed is reduced. Thus—

$$\frac{3}{6\frac{5}{8}} : 6\tfrac{5}{8} :: 1\tfrac{1}{4} : ? = \frac{24}{53} : \frac{53}{24} :: 1\tfrac{1}{4} : ?$$

and

$$\frac{53 \times 53 \times 5}{24 \times 24 \times 4} = 6{\cdot}09 \text{ inch diameter.} \quad \text{Answer.}$$

The Importance of the Twist Wheel.

The twist wheel is by far the most important wheel about the frame. It is fixed on the inner end of the jack shaft, or main shaft of the frame, and, with the exception of the spindles, it is connected more or less to every motion about the machine. It drives the top cone drum shaft, and from the end of this latter shaft is connected a train of wheels by which the drawing rollers are driven. Through the medium of the cone drums it is connected to the lifter and differential motion. If it were pulled off and the frame started the rollers and the lifter would stop, the spindles would go on as usual, and the bobbins would keep on revolving; but in a bobbin leading frame they would revolve at a reduced rate, so that no winding could take place. The chief duty of the twist wheel, of course, is to regulate the twist. This is done by putting a smaller wheel on when more twist is required, as when going on finer counts of roving. This smaller wheel drives the rollers more slowly, and allows the spindles to revolve at the same rate as previously, so that the same revolutions of spindle are made to a less delivery of roving, which, of course, means more twist per inch. A larger twist wheel puts less twist in by causing more material to issue from the rollers to a fixed number of revolutions of the spindles. It is not so easy to see the exact effect of a change in size of twist wheel upon the lifter speed and the differential motion. Suppose we change to a finer hank roving, and we put a less twist wheel on, what effect will it have on the lifter and on the sun wheel? As regards the lifter, it is made to go more slowly by a less twist wheel being put on, and the author has known many carders to imagine that no further attention need be paid to the lifter speed. This may do for a small change, but not for a change of any magnitude. In this case the less twist wheel slowers the lift so much as to compensate for the slower rate at which the rollers deliver the roving. But this does not meet the case. The lifter, in addition, requires to be traversed more slowly to compensate for the roving

being thinner, with which effect the twist wheel has nothing to do. As the lifter wheel is more usually a driving wheel, it follows that a smaller lifter wheel should be put on for finer counts, as well as a less twist wheel. This lifter change is often neglected for a small change in counts or hank roving.

In changing to a finer hank roving, the smaller twist wheel put on will cause the sun wheel or winding-on wheel to revolve more slowly, and therefore the winding revolutions of bobbins will be reduced, which means fewer revolutions of bobbin in a bobbin-leading frame, but would mean increased revolution of bobbin in a flyer-lead frame.

In either case compensation is made in the winding for the reduced rate at which the roving issues from the rollers due to a smaller twist wheel. This is correct for first layer, but immediately afterwards it becomes necessary all through the set to make compensation in the winding-on for the thinner nature of the roving, as well as its slower rate of delivery from the rollers. As every layer of roving put on the bobbin is thinner than on the former hank, it is necessary to ease the winding at each change to a smaller amount than before, and this is effected by applying a so-called larger ratchet or rack wheel, i.e. one with more teeth, but of the same diameter, so that each tooth or half tooth now means a less amount.

A change in the size of the twist wheel affects the speed of nearly every working part of the frame excepting the spindles upon which it has no effect.

A twist wheel of double size would :—

1. Double the speed of all rollers, roller traverse, stop-motion and indicators worked from rollers.

2. Double the speed of the top and bottom cone drums, and therefore the lifter speed, and the winding-on revolutions of bobbins (not the actual speed of bobbins).

3. The lifter would therefore reverse the builder motion and the changes would be made in half the time.

The twist wheel compensates in the winding on for the altered rate of roller delivery, but does not allow for winding alterations in regard to counts or hanks, this being the function of the ratchet or builder wheel. The lifter speed is also altered by the twist wheel to compensate for increased roller speed, but the lifter wheel must compensate in lifter speed for the counts or hank being altered.

The Rack Wheel.

The ordinary plain rack wheel, working half tooth at each lifter reversal, remains the favourite, but its effect and final exact size are always doubtful and subject to experiment due to such items as the following :—

Times of cotton round presser or amount round flyer top. The amount and proportion of twist put in the roving. Variations in moisture, or even in temperature. Comparative degree of perfection in smoothness of all parts of flyer and presser touched by the cotton. Character of the cotton. Exactness of hank roving obtained.

Twist Alterations on Roving-Frames.

In most cases an ordinary single carrier wheel, with one driving twist wheel, and one driven wheel on top cone shaft provides all the convenience in twist per inch alterations required in actual practice, and is the most common application.

Sometimes, however, it is desired to spin yarn on the roving-frame, and it is difficult to get sufficient twist per inch even with a very large carrier. Before now the writer has used a mule back drawing-out wheel in this connection.

To meet such cases a double carrier wheel may be used to give two small driving wheels and a double speed purchase as in the second or middle part of Fig. 71.

To get a very low twist on the left part of Fig. 71 there are two large driving wheels used. The third or right-hand part of figure shows yet another possible combination. The four possible combinations are: (1) three wheels; (2) four wheels; (3) five wheels and a double speed reduction for very high twist; (4) five wheels with only one

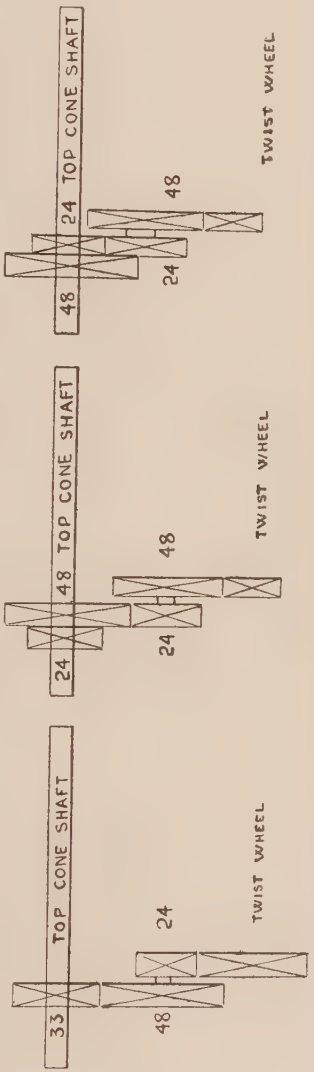


Fig. 71.

purchase utilised. Not only must the right twist per inch be got, but also a good wheel gear.

Flyers.

In a manner of speaking the flyer of a bobbin and fly-frame is one of the most ingenious and most highly developed mechanical details used in cotton spinning.

It needs to be closely grained, highly polished and smooth, cleverly balanced, the paddle or press exactly suited to the class of work and speed of spindle. The hole at the top, and the one in the side of the flyer top, need to be of correct size for the class of work, and cross-pin at top well fitted; manner of fastening the paddle to hollow is of great importance, a simple hooking being often preferred, while in other cases a snug of brass or other material is preferred. Whether the cotton shall be three-fourths or other one-fourth round the flyer top, and whether it shall be one, two, or three times round the press finger are matters of primary importance.

An astonishing number of times handling and many different tools go to the make up of a flyer before it is ready for the mill. Flyer making, flyer using, and correct flyer adaptation are matters of great importance in getting the best mill results. Amount round flyer top and presser, distance below and in front of rollers, effects of centrifugal and centrepetal force, pull of the cotton, curvature of paddle, air resistance are all great factors.

Cast-iron flyers were tried at one time but quite failed owing to inability of getting a good finish inside the hollow leg, and to numerous breakages in making and using.

Numerous British and Foreign patents have been taken out for flyers.

Flyer Top Details.

The roving should pass either one-fourth or three-fourths round the flyer top in the direction of rotation. Careless tenters sometimes pass the cotton backwards and a soft loose end is produced. The side aperture of flyer top being slightly out of centre with the spindle centre, this carries the roving round in a small circle and helps to put twist in. Short, strained lengths of roving are much increased in length on the mule or the ring-frame.

When the side aperture of flyer top is nearest the rollers the length of cotton from flyer top to side aperture is about $\frac{1}{10}$ inch shorter than when the side aperture is on the opposite or farthest from the rollers; this causes a perpetual small vibration of the cotton or slight tightening and slackening, not conducive to good work, although the cotton is always sufficiently soft to yield. Diminished thickness of spindle top and of vertical hole in flyer top would

tend to reduce above evil. In a rover the defect may occur about every $\frac{1}{3}$ inch of cotton.

There is a much greater length of soft cotton rove from roller to flyer top in the front row than in the back row, and this of itself tends to produce a slight extra stretching of the roving on the front row, as well as exaggerating the little evil just mentioned. Three times round presses in front row and twice round in back row is considered good practice by many carders on Egyptian

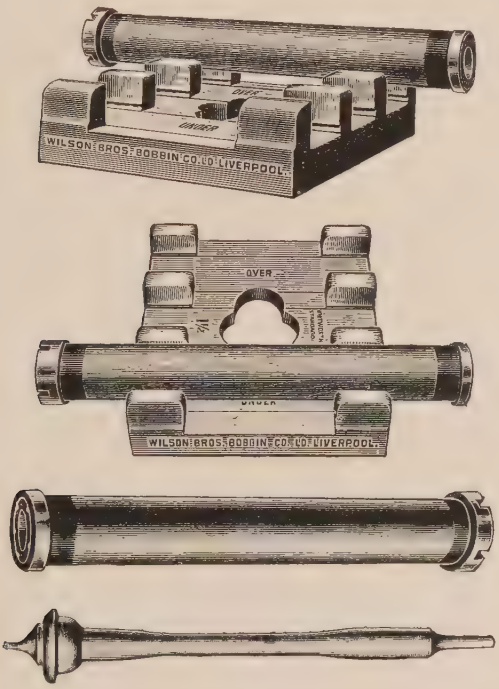


Fig. 72.—Messrs. Wilson Bros.' gauges for testing accuracy of bobbin diameters. Also a typical skewer and bobbin (see also p. 319).

cotton, to get front row bobbins as hard built as back row. Practical men well understand that new flyers may cause drag on the cotton through insufficient polish and smoothness, but some flyers are much worse than others in this respect.

The Presser.

The increasing diameter of bobbin takes the presser farther from the centre and increases its centrifugal force, thus causing it

to press on the bobbin less and less as the bobbin builds up. In cases of comparatively heavy presses and three times of cotton round presser, this shows up very little. It has proved a very definite factor in cases of presses rather under-weighted in relation to the leg of the paddle.

Double press flyers maintained a balance all through the set when in good order, but were discarded through getting out of order and their first cost.

A single press flyer may be balanced in middle of set, or else to always give the weight to the presser.

Distance and Height of Flyer Top in Relation to Rollers. Parallelism of Rollers.

It is a somewhat debatable point as to what is the best distance of spindles in front of rollers, and of spindle tops below the rollers in slubbing. Intermediate roving frames, for coarse, medium, and fine work respectively.

The problem is distinctly complicated by the modern system of working a double row of spindles on all these machines.

This problem became so troublesome on ring-frames that inclined roller stands were adopted in order to permit the twist to run up to the point of roller delivery. Although inclined roller stands have not been adopted on fly-frames, there are some carders who adopt the idea of setting the top front roller leaning towards the front of the steel roller in order to favour the twisting effect.

Spindle tops too low down permit the rovings to rest over much on the bottom steel roller. Spindle points too high up, with the front ends almost horizontal, tend to put too much strain on the cotton, and produce too much rubbing on the flyer top, and the conditions generally are scarcely as favourable to easy insertion of the twist, although the twist runs better up to the delivery point. An inclination of 12° for fly-frame rollers might do good.

In any case care should be taken to have the top rollers set truly parallel to each other and to the steel rollers, or there will be a distinct variation of roller grip on the thin cotton strand, such variation being increased by the operation of the roller traverse motion.

Judgment by the eye and results, using a straight edge of some kind against the faces of the rollers, methods of setting either between the leathers or between the cap nebs as deemed best may be helped by using special elaborate setting gauges now available.

Flyer to Roller (Fig. 73).

It is obvious the length BAD is greater than the length BAC, and this variation in length and vibration of cotton may occur about

500 times per minute on a slubber, 600 or more on an intermediate, and 1,000 or more on a roving-frame.

At T it is shown that the point A^1 is much lower down and much nearer to B, in relation to the rollers, than the corresponding position at S.

Such differences are open to great matter of opinion and some difference in practice, and it is interesting to consider possible effect on twisting, winding, and cotton rubbing problems.

Before now some carders have adopted a top roller setting which gives a lean forward as at T in order to slightly imitate the effect of the inclined roller stands on a ring-spinning frame.

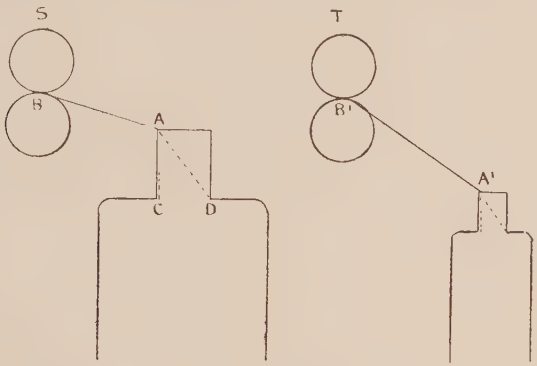


FIG. 73.

Divided Lifters and Balancing.

In cases of very long frames it has often been deemed best to practically put two very short frames end to end, with driving at each end, certain parts being common, and others on their own.

Where there is good work, few end breakages and limited creeling, it has enabled one tenter to look after more spindles.

Apparently in America this divided frame idea has been utilised to obtain another effect. The lifter rail has been made in two halves, split in the centre of the frame length, and arrangements made by which one half the length of lifter moves up while the other moves down. Connections are formed by which one half lifter automatically balances the other half, and not only does this dispense with the heavy balance weights but it helps to maintain an equal balance for all diameters of bobbin. Referring now to the ordinary frame and single lifter, the author is of opinion that it would pay to apply automatic arrangements for adding to the balance weights as the bobbins increase in diameter, and there is room for a little inventive ability in this detail.

Milled racks and cut rack pinions, lifter balancing by weighted levers which fit directly under the centre of the lifters, using lifter shaft bearings in which cast-iron bears on cast iron, are all helpful in maintaining easy and efficient working of the lifter. Accurate adjustment of long collars and of lifter, no binding in change motion parts help also in this respect.

Calculations.

Assuming you are required to arrange the drafts in the various machines from the scutcher to the roving-frame, what arrangement would you adopt in the following case :—Scutcher lap 14 oz. per yard ; finished roving 6-hank ?

A 6-hank roving would serve for possibly 46's counts of yarn spun from single roving. The scutcher lap is a shade on the heavy side for this roving, but would serve the purpose. This would be fed at the card and by using a card draft of 112, and allowing for 5 per cent. loss in waste, we should get a card sliver as follows :—

$$14 \times 437{\cdot}5 = 6125 \text{ grains in } 140 \text{ oz.}$$
$$8{\cdot}33333 \div 6125 = {\cdot}00136 \text{ counts of lap.}$$
$$\frac{{\cdot}00136 \times 112 \times 100}{95} = {\cdot}16 \text{ hank sliver.}$$

We could feed this ·16 sliver at the draw-frame, and produce a sliver of same counts for the slubber, putting up six ends together behind each of three heads of draw-frame, and using a draft of approximately 6 in. each machine.

At the slubber we could put up the ·16 sliver, and use a roller draft 4·5, thus giving $4{\cdot}5 \times {\cdot}16 = {\cdot}72$ hank slubbing. Now taking these ·72 slubbings and putting up two together behind the intermediate frame, and using a draft of 5, we obtain

$$\frac{{\cdot}72 \times 5}{2} = 1{\cdot}8 \text{ intermediate counts.}$$

Now taking this 1·8 intermediate hank, and putting up two together at the roving-frame, and requiring 6-hank roving, we find required draft at roving-frame as stated below :—

$$\frac{6 \times 2}{1{\cdot}8} = 6{\cdot}6 \text{ roving-frame draft.}$$

Obviously no two persons would be likely to get exactly the same answers all through, but approximately a like result should be obtained.

Bobbin Strippers.—There are bobbin strippers of vertical con-

struction in which the bobbin is placed on a spindle, a handle pulled, and the cotton rubbed off the bobbin. Quite of a different type are bobbin strippers in which several bobbins are placed between rollers. The war developed this latter kind.

One such machine consists of two 7-foot wooden rolls, one 4 and the other 5 inches in diameter. These rolls revolve toward each other. When the bobbin is laid in the angle between them, the stripper sees that the loose end of the roving is caught between the rolls. As the bobbin revolves in the unwinding of the roving, it also moves along the length of the rolls and falls into a box at the bottom.

This machine is an improvement in several ways over some others. More bobbins can be stripped by it; it in no way injures the bobbins; and it leaves the waste in better condition. That it is a safe machine for any employé to work on is another desirable feature.

Specification for New Fly-Frame.

The machinists may require a spinning firm to fill in specifications in regard to following details, and will be prepared to assist in such work:—

Number of frames; driven and geared in the ordinary way at one end only, or at both ends or in the middle for very long frames; length over all including end bearing; width available; the necessary widths being 4 feet for a slubber, 3 feet 2 inches for intermediate, and 3 feet for roving-frame. Gauge of spindles, i.e. number of spindles from centre to centre of roller stand including both rows. Spindles per frame; length of lift; approximate r.p.m. of spindles; spindle diameter, ordinary or self-lubricating spindle footsteps, long or short collars, paddle or presser to be level with bottom of flyer leg, or to come below this leg. Diameters of empty and full bobbins. Ordinary bobbin to lead or special flyer to lead; counts or hank of bobbin to be fed to and delivered from the frame, with approximate total draft; twist per inch, kind, class, grade, and staple of cotton to be used. Diameters of top and bottom draft rollers for all three lines, and kind of weighting for top rollers; also whether the back and middle steel rollers shall be case-hardened in the necks only, and the front lines case-hardened all over; also whether the front top rollers shall be loose bosses, and shall have one or two threads per boss. Hand of pulleys when facing spindles. Description of top and bottom clearers for the rollers, and whether to be delivered to mill covered or uncovered. State whether separating plates are wanted for the slubbing frame. Minimum and maximum roller centrings required. Disengaging motion. Kind of creel, total length of creel skewer, full diameter of creel bobbins. Kind of main driving, whether rope, gallows pulley drive,

or $\frac{1}{4}$ crossed belt, along with r.p.m. of line or counter shaft and width of belt. State if a brake motion is wanted. Kind of differential motion and swing motion, kind of roller traverse motion, indicator, and knock off desired.

Hetherington's Specification Sheet.

Details to be given when ordering Speed Frames.

How many frames? How many spindles in each frame?
To stand in what length including driving pulleys?
Length of lift? inches
(Usually 10, 9 or 8 inches.)

NOTE { The gearing occupies 3 feet $\frac{1}{2}$ inch for single driven frames. Width of frame 3 feet.

For soft or press bobbins? What description of presser?
Diameter of bobbin when full? Diameter of bobbin barrel?
Flyer or bobbin to lead?
If with short collar? or Mason's long collar? extra per spindle at
Diameter of spindle? (Usually $\frac{3}{4}$ inch.) If with $\frac{13}{16}$-inch diameter extra per spindle, at
Spindles to run twist or weft way? (Usually twist way.)
If with patent footstep extra? at
Which gauge will you have?

Is the front line of bottom rollers to be case-hardened? extra per spindle at

Diameter of Fluted Rollers.	
Front	inch
Second	,,
Third	,,

Or are the necks only to be hardened extra per frame at

Diameters of Top Rollers.	
Front	inch
Second	,,
Third	,,

Back line of rollers to have corrugated or common flutes?
If top rollers or front line to be E. Leigh's patent loose boss? extra per spindle at
Total draft of fluted rollers?
Draft from front to second roller?
Draft from second to third roller?
If baywood or iron flat top clearers?
Top spindle rail cased with baywood or iron?
Distance from centre to centre of rollers?
Front to second, smallest distance to open to
Second to third, smallest distance to open to
Top roller dead-weights for three lines of rollers:—

If middle and back top rollers self-weighted?
If three lines of rollers weighted separately with dead weights?
extra per spindle, at
Front lb. Second lb. Third lb.
Number of hank roving to be made?
Extreme length and diameter of creel bobbins?
Creel: if for two bobbins to each spindle? or for three bobbins?
at per spindle?
Height and diameter of coiler can?
Speed of main shaft per minute? Diameter of drum on same.
If with brake, extra at
Speed of spindle? revolutions per minute
How many turns of spindle for one of front roller?
Diameter of driving pulleys on frames? in.
Driving pulleys when facing spindles on right hand or left hand?
Hank indicators extra at each. If with separating plates for ends to run through? extra per spindle, at
NOTE.—The spare pinions, etc., supplied without charge for each intermediate frame are as follows:—
2. Draft pinions, 2 twist pinions, 2 lifter shaft pinions, 10 ratchet pinions, and 6 top rollers.
Is a complete set of change wheels wanted for each frame, or how many?
Change wheels wanted: Draft pinions, Nos. of teeth to
Twist Nos. of teeth to
Lifter shaft pinions, Nos. of teeth to
Ratchet, Nos. of teeth to
Are any spare articles to be sent in addition to the above?
When must the frames be delivered, and how?
REMARKS:—
Date Signed by

The Swing Motion.

Owing to the "swing motion" forming an epicyclic train of wheels—or one in which some of the wheels not only have ordinary rotation, but are also carried bodily through space—the rolling action of the carriers slightly increases the bobbin revolutions one way of the lift, and slightly decreases the bobbin speed the other way of the lift. The variation may represent about 1 per cent., and the compensating swing was introduced to counteract this and to prevent the resultant slight tendency to slacken and tighten the rovings. The compensating swing added a separate lever and fulcrum so as to produce an equal and opposite rolling effect, and from personal

observation of its operation the author can testify to the successful attainment of the desired object.

Complication of parts and liability for breakdown led to the compensating swing being discarded. Ordinary swing motions have been strengthened and improved but still occasionally give rather serious breakdown. Chain and wheel swing combinations are now sometimes adopted, and improved construction in these chains and wheels probably offer the best final remedy for the various swing motion troubles. Levers, cranks, or cams should be utilised to keep the chain uniform in tension for all parts of the lift. To test for gaining and losing we may slacken the cone belt and the main driving belt of the differential motion, hold or wedge stationary, the first wheel of the swing on the frame shaft, wind the lifter fully up and down by hand; then note carefully the amount of bobbin revolutions due to this vertical action only. With slackly tensioned ends on a slubber, the ends may be seen going slacker as the lifter approaches its limit, perhaps more often when winding near the top end of the bobbin.

The Erection of a Fly-Frame. Floor Level.

Although not nearly so long as a mule, yet a fly-frame is sufficiently long to discover inequalities in the floor level—great in cases of old or carelessly built floors—less under better conditions of building. The strength and construction of any ordinary fly-frame permit its erection to be accommodated to any reasonable floor inequalities.

Method.—Position of frame having been fixed, traverse the proposed length by means of a long wooden parallel straight edge with a spirit level on top, and level the straight edge by suitable packings. Leave packings in position, or make measurements. Do this over the full length of frame and the packings will give the level forthwith.

A second method is to connect two water vessels—one at each end of the presumed position of the frame—with suitable tubing, and depend upon the principle of water finding its own level, in showing up any variations in floor level. Similar methods may be applied to a mule or other long machine.

Line up of Frame.

It is customary to have a frame at right angles to the line shaft, whether gallows pulleys are used or not. It is advisable to have the line shafting in position before starting the erection of a frame. First reproduce the line of the top shafting on the floor by droping two plumb lines therefrom, a few feet apart, and connect these two marks by a chalk line made from chalked string or by other

means. In doing this take notice of any variations in line shaft thickness.

From a central point on the first floor line mark off equal distances on either side. With a sufficiently long radius, wood or string, or other compass arrangement describe intersecting arcs from each of these two points, and in line with the central point. Connecting our original centre point with the intersection will give a straight line for the frame length, and to which the roller beam, bobbin rail, and spindle rail may be parallel.

The chief object of this right angle alignment of frames and line shaft is to obtain correct working and driving of the belt.

From actual experience the author is not enamoured of direct individual motor driving for fly-frames, on account of sudden starting noise, and having to reduce the motor speed down to the frame shaft speed by a large wheel driven from a buffalo hide pinion, or equivalent.

Actual Erection of Fly-Frame.

Obtain chalk line on floor as above. Lay all the beams along the chalk line in consecutive order of 1-1, 1-2, 2-3, 3-4, etc., starting at gearing end. Place gearing end in position and loosely bolt to it the first piece of beam and attach spring piece for this beam. Carry on to the other end with beam pieces and spring pieces, using the iron washers for the spring piece vertical setting-screws. Level the roller beam end to end with spirit level, string and blocks, allowing $\frac{1}{8}$-inch drop in tightly pulled string for 35 feet. Fix up the gearing beam between first spring piece and gearing frame end. Also the beam for the change or building motion between second and third spring piece.

Next fix top cone drum shaft in position, and then the lifting shafts, using the spirit level, and exercising the greatest care to have level, free-running shafts.

Every spring piece should be tested with a jigger or side level and made perfectly vertical. Then fix the bottom rails, and afterwards the top rails or lifter, with thick wood packings between top and bottom rails.

Attend further to the lifter by such items as the slides, vertical racks, chain-levers, and balance weights.

All top roller weights may be hung at this stage, and again try the line end to end of the roller stands. Considerable attention may now be given to gearings and covers.

Line up and adjust the spindles and collars and see that every spindle revolves very freely. See that all skew wheels for both spindles and bobbins are nicely geared.

It is all the better if one half of the set-screws on the long lifter,

bobbin, and spindle rails come on one side of the shaft and the other half of screws on the other side.

The erecter will have been keeping his help employed in properly cleaning all the parts of the frame. Especially must all steel draft rollers, and all flyers be well cleaned. Steel rollers put together according to consecutive numbers and letters. Finish up all details of creels, clearers, traverse, knocking-off, or any remaining work; run spindles and rollers for some time without cotton.

Settings and Gaiting-up.

The chief are as follows:—

Adjust the hanger-bar or tapering rod to be horizontal in the centre of the lift. See the bowl is free in double slide at all times. Adjust the two jack screws to change the lifter with the presser eye in line with extreme winding on point at each end of the lift.

Set the roller centres according to length of fibre and thickness of cotton; also properly parallel. Set the roller traverse motion. With strap on fast pulley, the stop-rod collar should be barely clear of the knock-off fork or lever. The inside of flyers may be cleaned with the aid of a soft untwisted piece of rope well covered with French chalk.

Slots in spindle tops to be well cleaned out and flyer tops all level.

Apply all change wheels as per requirements and experience.

In regard to winding on, the cone belt should be started at the extreme thin end of lower or driven cone drum and thick end of upper cone, or perhaps about 1 inch from end of cones, to allow for adjustment.

The winding wheel should now be adjusted to give a correct tension to the roving for first layer, end to end of empty bobbin. Afterwards the star wheel should correctly rule the tension—a larger wheel to give tighter winding. The coils of roving may be so disposed that they neither over-ride on the one hand, nor are too wide on the other hand, and a good rule is just to be able to definitely and distinctly notice the side by side coiling arrangement. Adjust the star wheel to change half a tooth at each lifter reversal, and endeavour to get the frame working from beginning to end of set without the tenter either "winding back" or "letting off" at the star wheel.

Adjust the full-bobbin stop-motion at the completion of first set.

Cleaning, lubrication, and testing of nuts and set-screws require special attention when first starting any new machine. Centre to centre of front and middle rollers may be $\frac{3}{32}$ or $\frac{1}{16}$ inch greater than length of cotton fibre on roving frame; plus to this another $\frac{1}{16}$ inch for intermediate, and $\frac{1}{4}$ inch for slubber.

Correctness in tension of winding and spacing of coils are of fundamental importance.

There should be no dislocation of weight hooks, or binding of roller weight wires, that will hinder the full weight coming on each top roller.

Manipulation of Fly-Frames. Instructions by an Eminent Firm.

Oiling and Cleaning of Fly-Frames.—"All bearings must be oiled once a day, and the bearings of quickly running shafts twice. The spindle collars are to be oiled twice daily, and the spindle footsteps if provided with oil reservoir once a month. The spindle collars must be thoroughly cleaned inside every nine months. The chains and chain bowls for the balance weights, as also the rail slides, must be oiled and greased once a week. It is exceedingly important that the bobbin and spindle shaft steps be constantly provided with tallow, and in addition to this that they be oiled once a day.

"The differential motion should be oiled every two days.

"On fly-frames with electric stop-motion, do not omit to oil the steps and necks of the stop-motion rollers every day. This may be easily overlooked, as they are in the creel.

"The whole of the gearing must be oiled or greased from time to time.

"The fly-frames should be cleaned through every three to six months, according to need. On this occasion the drawing rollers should be taken out and the flutes of same thoroughly cleaned; the roller steps should also be freshly greased.

"If the middle and back top rollers are weighted by weights, the necks should be treated every two days with a mixture of oil and fat applied with a brush. The necks of the top rollers, if self-weighted, must neither be oiled nor greased; at the most, they may only be treated with black-lead, mixed with water to the consistency of a paste, and applied with a brush. The centres of the front top rollers must be oiled once a week, and care must be taken that not too much oil is applied, and that it does not get on to the leather covering of the rollers.

"The top roller leathers must be periodically examined, and either re-covered or ground up again. The front top rollers must be re-varnished once a week. Also, the traverse motions must be kept in good condition, as this ensures a considerable economy in leather.

"Care must be taken that the middle and back self-weighted top rollers do not vibrate, i.e. move backwards and forwards on the fluted bottom rollers, as this would cause cut and uneven yarn. This vibration can be avoided by setting the top rollers back on the

fluted rollers. On doffing each set the fly should be wiped off the roller beam, the roller stands, iron flats, creels and spindle, and bobbin wheel casing plates. The slots at top of spindles must be cleaned once a month.

"All rollers must be cleaned once a week. The fly must be taken off the top clearers, if stationary, five times a day, and off the under clearers once a day."

The flyers may be wiped twice during each set, viz. once when the bobbin is half full and once when the bobbin is full. In some cases this work is only done at doffing times.

Spindles.

Spindle diameters may be $\frac{3}{4}$ inch for slubber and intermediate, $\frac{5}{8}$ inch for roving and fine jack-frame. High speeds sometimes take $\frac{1}{16}$ inch more in each case excepting the fine jack-frame.

Long collars have become quite the accepted thing, excepting for low spindle speeds.

Revolutions of spindle per minute for American cotton may be about as follows: Slubbing 550 to 600, intermediate 700 to 800, roving frame 1,100 to 1,200.

Short collars would mostly require rather lower speeds in order to maintain freedom from vibration.

Egyptian cotton requires less twist per inch and will usually take 50 to 100 r.p.m. lower than American, and yet maintain the hanks production per week. Slubber 450 to 500, intermediate 600 to 700, roving frame 1,000 to 1,100, fine jack 1,150.

For American cotton the lifts may be 10 inches for slubber and intermediate, and 7 inches for roving frame.

For low counts of $3\frac{3}{4}$ hank roving or lower the intermediate frame is sometimes dispensed with and the slubber may take up to 12 inch lift, with the rover 8 inch lift.

Hollow spindles have been obtainable for some time as well as light collars instead of the heavy cast-iron ones, both aiming at retaining all the strength of the heavier spindles and collars with great reduction in weight. The hollow spindle is made from weldless steel tubing suitably prepared at the upper end to carry the flyer and having a steel stud fitted at the lower end to fit in the footstep.

Cone Drum Raising.—Arrangements for lifting the lower cone drum and slackening the cone belt for doffing purposes, should be prompt in action, hold the cone drum rigid in any position, and perhaps operated from the front of the frame. It should be feasible to tighten a cone belt by moving the lower cone to a lower position and yet keeping its shaft perfectly parallel with that of the upper cone. The bottom cone sometimes wants holding still, while the rovings are run slack for doffing.

Full-bobbin stop-motions are operated from the front roller when it is desired to check the exact length of cotton delivered to each spindle. Even then variations in winding-on in bobbin draft, and in counts or hank roving, affect the correctness.

In many cases the knock-off is obtained from some connection to the traverse of the long rack or cone drum belt.

Framing.—In one case the top of the roller beam is stated to be 2 feet 9½ inches from the floor for 7-inch lift, 3 feet 2 inches for 10-inch lift, 3 feet 6½ inches for 12-inch lift. A low framing may facilitate creeling and cleaning. Short tenters may use a low buffet to stand upon, or a thick extra plank may be nailed on the floor.

The frame ends, roller beams, spring pieces, pedestals and brackets are planed or milled and steady pinned in position where necessary, so as to prevent or diminish later readjustments. Spring pieces have adjustable feet to allow for unlevel floors. Spindle and bobbin rails are milled to receive collars and spindle footsteps.

Fly-Frame and other Machinery for 30,000 *lbs. Per Week of Combed Rovings.*

As a basis we might assume that the fine jack-frame is used to produce twenty hank rovings, with a spindle speed of 1,050 r.p.m., diameter of full bobbin 2½ inches, each full bobbin to contain 6 oz. of cotton, 1¼ inch diameter of front roller, 6-inch lift, thirteen minutes per set lost in doffing; 62 r.p.m. of front roller, giving 4·248 turns per inch, hanks per spindle per week 27·29, which comes to 1·364 lb. per week per spindle:—

30,000 ÷ 1·364 = 22,000 (almost) jack-frame spindles.

Assuming the roving frame to produce 4½ lb. per week per spindle of 7 hank roving, and not allowing for waste, we get:—

30,000 ÷ 4·5 = 6,666 roving spindles.

Assuming the intermediate frames to produce 13·4 lb. per week per spindle of 3·5 hank, we get:—

30,000 ÷ 13·4 = 2,238 intermediate spindles.

Assuming the slubbing frames to be making 1·5 hank and producing 32 lb. per spindle per week, and without allowing for waste, we get:—

30,000 ÷ 32 = 937·5 slubbing spindles.

It would be necessary to divide each total number of spindles by number of spindles per frame to obtain number of frames of each kind. By using four passages of fly-frames we do not need to make a very fine hank drawing or carding, and the production may be assumed to be 440 lb. per delivery can at the delivery of each card, comber, or draw-frame.

$30{,}000 \div 440 = 67$ finishing draw-frame deliveries,

with an equal number of card and middle boxes. It is sufficiently near for our purpose to take the number of combers also at about 68 to 70. Allowing, however, for the comber to make 20 per cent. of waste, we shall need many more cards. Assuming that 100 lb. of cotton fed to the comber gives 80 lb. of good sliver, what weight must be fed to the combers to produce 30,000 lb. of sliver?

$$\frac{30{,}000 \times 100}{80} = 37{,}500 \text{ lb. from cards.}$$

$$\therefore\ 37{,}500 \div 440 = 85 \text{ cards.}$$

We might assume ten or eleven ribbon machines and the same number of sliver lap machines. Then say three scutchers and two openers suited for good Egyptian cotton.

Doffing of Fly-Frame.

Doffing a roving frame is an exceedingly simple process. The frame is stopped with the pressers some distance away from the end of the bobbin, and not so far away from the middle position, so that the ends of roving will not drop loosely over the ends, and make waste. The cone belt is slackened, and the two racks are wound back by the proper hand-wheel, so as to place the cone belt near the thin end of the driven or convex cone drum, and also to place the out end of the diminishing rod or hanger bar in its farthest position from the building motion. In this way the winding-on is again made right for the empty bobbins and the lifter is again caused to move through its maximum traverse. The empty bobbins having been made ready before stopping the frame actual doffing or changing full for empty bobbins may now take place, although previously the frame must have been set on a very little with the cone belt slack in order to run small bunches of roving on the flyer tops to give slack cotton for doffing convenience. It is one detail of practice to place the flyers of the front row of bobbins upon the flats out of the way while the bobbins are changed, but to simply lift the flyers of the back row and then at once drop them back after changing bobbins. Empty bobbins having been put on, the flyers are replaced and each cotton end fastened to its bobbin. Care is taken to have the cone belt re-tightened and then the frame is re-started for the new set. Occasionally disengaging motions are used for starting the lifter at one end.

Doffing Allowances.—A slubber may take six or seven minutes for doffing and two and a half hours weekly for cleaning.

An intermediate eight or nine minutes per set for doffing and three hours weekly for cleaning.

A roving frame or fine jack-frame may take twelve minutes per set for doffing and three hours weekly for cleaning.

Separating Plates.—Polished separating plates are frequently used on slubbing frames to prevent broken ends from flying about and breaking other ends down.

They are scarcely needed on intermediates or roving frames.

Brakes.—For high speed frames sometimes a $\frac{1}{4}$ circle brake motion is made to bite on the edge or rim of the fly-wheel when the stop rod is moved to stop the frame. In this way the frame is stopped more suddenly, but long frames and low speed frames will usually stop sufficiently soon without brake. Sliding the stop rod to start the frame lifts the brake away from the rim of the fly-wheel.

Empty Bobbins.—All new empty bobbins should be tested at the mill for exactness of diameter. Variations in diameter always affect the tension of the rovings, larger diameters giving tighter winding.

In starting a new fly-frame there is often extra drag on the roving for some time until the cotton has polished its own passage all along the flyer. After a time a larger star wheel may be applied.

Reversing Motion (Messrs. Asa, Lees & Co.).

The reversing motion, or changing motion, controls the reversing of the lifting rail, the movement of the cone drum belt, and the shortening of the anchor bar to shorten the lift and give the required taper to the bobbins.

The important feature of this motion is the special method of charging the springs for moving the reversing bevels in and out of gear, the effect of which is a quick change and an easy movement of the cone belt. Referring to Fig. 74.

Fixed to the lifting rail is the radial slot bracket J, which, in moving up and down with the rail, causes the bell crank lever H to rock the horizontal reversing lever G, connected to which are two springs F, suspended from two arms on the reversing bracket E.

The reversing catches D are released by means of the screws C, which rock with the motion of the anchor bar B, and with the special method of charging the springs the anchor bar has nothing to do but rock the cradle in which the screws C are fixed, whereas in other motions, the anchor bar itself has to charge the reversing springs to a sufficient tension to move the reversing bevels in and out of gear, which puts a great strain on the anchor bar and prevents the easy movement which is essential to the making of a well-shaped bobbin.

References to Diagram.

A Anchor bar slide.
B Anchor bar.
C Adjustable screws for releasing catches.
D Reversing catches.
E Reversing bracket.
F Reversing springs.
G Horizontal reversing lever.
H Bell crank lever.
J Radial slot bracket.
K Ratchet wheel catches.
L Adjustable stop bracket for catches.
M Ratchet wheel.
N Long rack.
O Reversing rod bracket.
P Fork bracket for reversing bevels.
Q Reversing bevels.
R Catch to operate knocking-off motion.
S Bell crank lever for knocking-off motion.
T Latch for knocking-off motion.
U Spring for knocking-off motion.
V Long knocking-off lever.
W Weight for knocking-off lever.

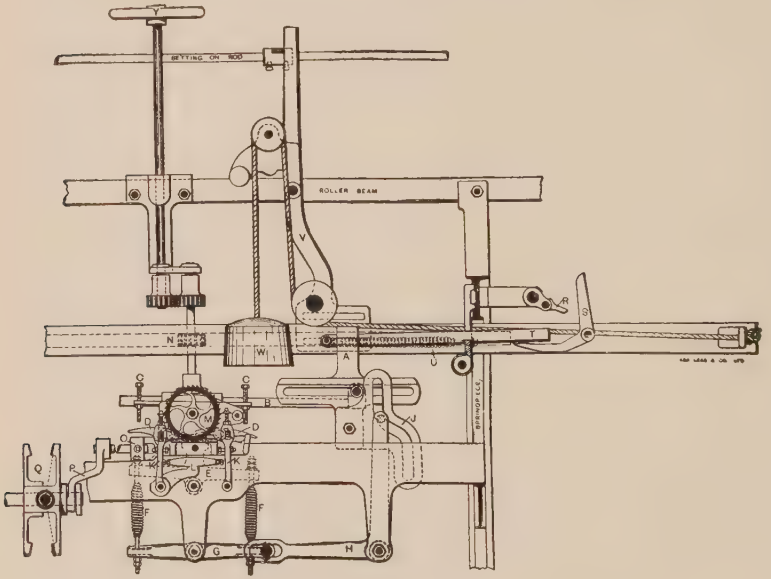


FIG. 74.

The pinion which gears in the anchor bar is the change place for altering the taper of the bobbin, and can be very easily changed.

Hanks and Counts. Fly-Frames.

Fly-frame counts or hanks for different counts of yarn. Advised by an important firm.

Egyptian Cotton. Counts of Yarns.	Double Roving. Slubbing.	Double Roving. Intermediate.	Mule Spinning. Roving.
50's	1	2·5	10
60's	1·2	3	12
70's	1·25	3·5	14
80's	1·325	4	16

American Cotton.	Single Roving.	Mule or Ring-frame.
	Slubber. Intermediate.	Rover.
12's to 20's average 16's	·6 1·2	2·75
16's ,, 24's ,, 20's	·6 1·5	3·5
24's ,, 32's ,, 28's	·7 1·75	4·5
36's ,, 40's ,, 38's	·8 2	5

In a ring-frame the take-up by twist has more scope than with the receding carriage of the mule, and slightly more draft may often be wanted on the ring-frame than the mule, to spin equal counts from equal back bobbins. Some firms prefer to give a slightly coarser back bobbin to the mule.

Drafts should be slightly progressive as the thinner the cotton strand becomes the more draft it will take at any one machine. A thick strand of cotton resists draft more than a thinner one.

Slubber about $3\frac{1}{2}$, intermediate $4\frac{1}{2}$, and rover 5 to $6\frac{1}{2}$, represent average practice for American cotton, and rather higher in each case for Egyptian. Double roving compels higher drafts.

Single roving at slubber and double at all other fly-frames for all counts is the usual custom. At the mule or ring-frame, single roving for American and double for most Egyptian and all Sea Islands.

Roller Weighting.

All three lines of top rollers on all passages of fly-frames are usually dead weighted for American and Indian cotton. For Indian cotton there may be a separate weight for each line of rollers, but usually for American cotton and sometimes for Indian, each front roller has a weight to itself, while the back and middle are saddled together and weighted by one and the same weight. Lever weighting is seldom applied to fly-frame top rollers.

For long staple Egyptian and for Sea Islands cotton it is quite common to have the front top line only dead weighted, and backs and middles self weighted, or ordinary roving frames and fine jack-frames; sometimes also on slubbers and intermediates, but some prefer to have only the back top roller self weighted on these machines—and especially the slubbers—because they consider the self-weighted middle rollers do not sufficiently draft out the tenter's piecings.

A self-weighted middle top roller on fine roving frames sometimes enables a little setting inside the fibre length front and middle centres, with the object of getting more regular drafting. The thicker nature of the cotton at slubber and intermediate stops this idea on these machines.

The Paddle or Presser.

The author is acquainted with a case in which the presser has lately been adopted for rovings intended for 250's yarn. The roving

passes just through the eye only, and twice as much cotton is got on a bobbin.

This hardens the bobbin by always pressing thereon due to the centrifugal force of the leg being greater than that of the paddle; also by holding the cotton very close to the bobbin, and by having the cotton wrapped once, twice, or thrice round the paddle.

Up to about 12-hank the three times round method is probably the best as it gives distinctly harder and more nicely built bobbins.

Twice round is deemed sufficient by most people for finer hanks. The size of ratchet wheel may be affected by changing from one to the other. In an ordinary bobbin-lead frame there is probably more work for the cone belt for three times round paddle than for twice round. Weights of paddles vary somewhat. Paddles may be either level with leg or somewhat below, the first named being stronger and much less liable to be bent or knocked out of shape. Consequently, it is the favourite except for fine rovings, on which the paddle below method is often preferred because it apparently puts somewhat less strain on the roving. Against this fly sometimes drops on the lower placed paddle and after accumulating somewhat passes on the bobbin as a bad end. After picking flyers, a tenter should just go through them again to pick off any bits of fibre sticking to the paddles. One-fourth round back row and three-fourths round front row on flyer top, is sometimes taken as a remedy for softer winding in front row due to greater distance from rollers. Always pass the cotton round the flyer top in direction of revolution or softer strands and bobbins will result.

The first centripetal presser was invented by Hilton Wilson of Preston in 1853, and in 1856 Wm. Ryder of Bolton patented a centrifugal presser.

A brass lump presser fastened on top of presser was later introduced, and as the bobbin fills the lump works round the flyer tube, the presser being kept in position by the end of flyer tube.

The Presser.—In connection with the presser many experiments have been made, producing both good and bad results. Some maintain that so long as the length of staple is within the point of winding and the pressing point, it does not matter how severely the presser strikes, so long as unwinding proceeds all right at the next machine.

Per contra, there are advocates for a light presser, so as to produce an easy winding, but sufficient to prevent the roving from falling off the bobbin later on.

The speed of spindle always exercises a strong effect on the work of the paddle and the hardness of bobbin, since a higher speed develops a great centripetal force on the presser and a greater pressure on the bobbin.

Double press flyers had both legs hollow, each leg having a

paddle. Much used for some years, but experience proved one paddle to be ample. While in good order, one press balanced the other for all sizes of bobbin.

Soft bobbins are still made on some frames for very fine work. The cotton carries directly from hollow leg to bobbin. There is no paddle or presser at all.

Frame Indicators.

The clock-face type of indicator for frames is now very little used.

The almost universal kind of indicator is one that shows ordinary numerals on the face, just as they would be written down when taking the indicators. (See Fig. 75.)

For example 48·3 in clock face means 48·3 hanks, 96·4 means 96·4 hanks, 00·0 means 100 hanks and the next change will be 00·1 which means $\frac{1}{10}$ hank.

There are two worm wheels in the combination—one driven

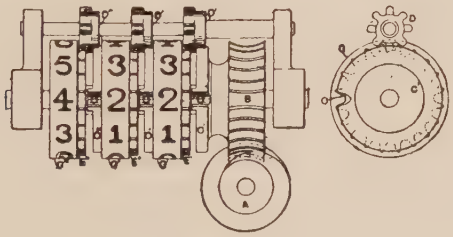


Fig. 75.

directly from front roller—and the other making the second driven wheel.

Afterwards there is 1 driving 4 and 8 driving 20 = $\frac{1}{10}$ repeated three times over. The worm wheels form a change wheel standardised to different diameters of front roller. For $1\frac{1}{4}$-inch F.R. the wheels are 39 × 20, for $1\frac{3}{16}$-inch F.R. 39 × 21. Other sizes in proportion, so that the indicator worked out should always reach as near $101\frac{1}{4}$ as can be, the $1\frac{1}{4}$ per cent. being to allow for "single" or "thick" pulled off, any empty spindles, or ends down generally.

Take $1\frac{3}{16}$-inch diameter of front roller

$$\frac{5 \times 22 \times 39 \times 21 \times 10 \times 10 \times 10}{4 \times 7 \times 1 \times 1 \times 1 \times 1 \times 1 \times 12'' \times 3 \times 840 \text{ yards per hank}}$$

$$= 101\tfrac{1}{4} \text{ hanks approximately.}$$

Were the answer much more than $101\frac{1}{4}$ it would be against the

tenter, who would be doing more than 100 hanks and yet only be paid for 100. Taken into account when fixing wage lists.

Intermediate Frame. Production Statement.

Orme's indicator making up time, Wednesday night, week of forty-eight hours :—

Frame No.	10.	11.	12.	13.	14.	15.
Wednesday . . .	10	2	—	—	—	50
Thursday . . .	22	14	—	—	—	62
Friday	34	26	—	—	—	74
Saturday . . .	40	32	—	—	—	80
Monday . . .	52	44	—	—	—	92
Tuesday . . .	64	56	—	—	—	4
Wednesday . . .	76	68	—	—	—	16
Total hanks per week .	66	66	—	—	—	66

No. 15 frame having reached the 100 limit of the indicator has re-started at zero and reached 16.

Some spinning firms only go to the trouble of taking the hanks once per week at the making-up time. This shows the total hanks produced for the week by each tenter or each frame, but does not show the exact date of any special loss.

On the contrary, some firms not only take the indicators daily, but a special daily production statement is made out for the management.

Assume a frame of 140 spindles produces 66 hanks per spindle per week, the hank intermediate being 2, the lb. per frame are obtained as below :—

$$\frac{66}{2} = 33 \text{ lb. per spindle,}$$

and $33 \times 140 = 4620$ lb. per frame less any stopped spindles.

Bobbin ratch, inexactness of counts, and stopped spindles disturb the accuracy of any such calculation.

Changing a Fly-Frame from Flyer to Bobbin Lead.

An operation frequently done in 1880 to 1900. Seldom done now because nearly all frames are bobbin lead.

Take a frame fitted with Holdsworth's differential motion. It would first be necessary to reverse the direction of rotation of the sun wheel, so that this wheel would begin to revolve in the opposite direction to the shaft instead of in the same direction. In this way

the sun wheel would now give extra revolutions to the resultant wheel of the motion and to the bobbins, and make the latter go faster than the flyers, whereas for flyer lead the sun wheel revolution retards the bobbins, and makes them go slower than the spindles. This alteration might be effected by taking a carrier out of the train of wheels connecting the bottom cone with the sun wheel. If this first alteration also made the lifter to move in the opposite direction it would be necessary to reverse one of the lifter driving bevels in order to put the lifter right again. With flyer lead the pressers follow behind the flyer legs to which they are attached, so it would be necessary to apply fresh flyers with the pressers pointing ahead of the flyer legs for the bobbin lead. The reasons for bobbin lead becoming prevalent are: (1) There is less waste from broken ends of cotton unroving from the bobbins and flying about. (2) There is no tendency for the rovings to be strained every time a frame is stopped and started. Both these evils are prevalent with flyer leading.

Drafts Scheme, Scutcher to Rover.

Scutcher lap 14 oz. per yard. Finished roving 6-hank.

A 6-hank roving would serve for possibly 46's counts of yarn spun from single roving. The scutcher lap is a shade on the heavy side for this roving, but would serve the purpose. This would be fed at the card, and by using a card draft of 112, and allowing for 5 per cent. loss in waste, we should get a card sliver as follows:—

$$14 \times 437{\cdot}5 = 6125 \text{ grains in } 140 \text{ oz.}$$

$$8{\cdot}33333 \div 6125 = {\cdot}00136 \text{ counts of lap}$$

$$\frac{{\cdot}00136 \times 112 \times 100}{95} = {\cdot}16 \text{ hank sliver.}$$

We could feed this ·16 sliver at the draw-frame, and produce a sliver of same counts for the slubber, putting up six ends together behind each of three heads of draw-frame, and using a draft of approximately 6 in each machine.

At the slubber we could put up the ·16 sliver, and use a roller draft 4·5, thus giving $4{\cdot}5 \times {\cdot}16 = {\cdot}72$ hank slubbing. Now taking these ·72 slubbings and putting up two together behind the intermediate frame, and using a draft of 5, we obtain

$$\frac{{\cdot}72 \times 5}{2} = 1{\cdot}8 \text{ intermediate counts.}$$

Now taking this 1·8 intermediate hank, and putting up two together at the roving frame, and requiring 6-hank roving, we find required draft at roving frame as stated below:—

$$\frac{6 \times 2}{1{\cdot}8} = 6{\cdot}6 \text{ roving frame draft.}$$

Obviously no two persons would be likely to get exactly the same answers all through, but approximately a like result should be obtained.

Draft Calculation on Fly-Frames.

Required to produce an intermediate bobbin of 1·2 hank from a 6-hank slubbing. What draft wheels would you use on a frame geared as follows: Front roller wheel 19 teeth, crown wheel 95 teeth, back roller wheel 60 teeth, bottom rollers $1\frac{1}{8}$-inch, 1 inch, $1\frac{1}{8}$-inch diameter? Is it usual to make any allowance in the wheel?

(*a*) $1{\cdot}2 \div 6 = 2$ roller draft if only single ends are put up behind the intermediate. It is more usual to put up double ends or two together, and this requires the draft to be:—

$$2 \times 2 = 4.$$

(*b*) By the ordinary draft rules we obtain the following calculation:—

$$\frac{95 \times 60}{19 \times 4} = 75 \text{ draft change wheel.}$$

There are two or three factors which may affect the exact size of this change wheel somewhat. For example, the twist may tend to shorten and thicken the roving, roller slip may have the same effect, while "spindle stretch" may exercise exactly an opposite effect. In any example for which data have not already been obtained from previous experience, it would probably be wise to put on the 75-wheel, wrap the produced bobbins as soon as convenient, and alter as required at the draft wheels.

Position of Jack Shaft.

Compensating swings have not proved a success; but it is the writer's opinion that the fixing of the differential motion centre near the centre of the lift prevents excess slackening or tightening of the rovings at one end of lifter traverse due to the swing being an epicyclic train of wheels.

Such variation in tension of ends does exist, and having much difference between these two centres accentuates the evil.

The evil is probably not worth troubling about very much.

Differential Motions.

There are several makes of modern differential motion in successful use, and their specific claims as compared with the old Houldsworth motion may be stated somewhat as below. In the first place they are probably quieter. They are so well boxed in,

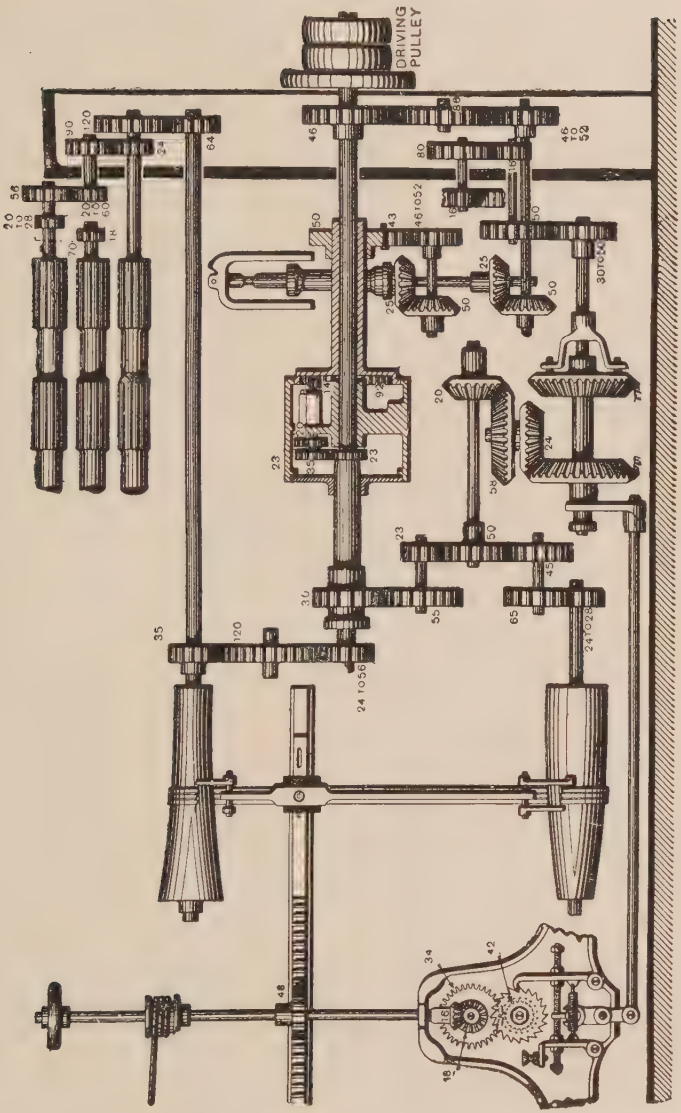


Fig. 76.

and such excellent means are provided for lubrication that this helps in working and in reducing wear and tear. Above and beyond

all, the internal or carrier wheels of the new motions always have a comparatively low speed, whereas in the Houldsworth motion the internal or planet wheels have a high speed, the contrast being especially marked in the earlier stages of building the bobbin. Furthermore, bobbin leading frames have become generally adopted, and in these frames nearly all the wheels of the Houldsworth motion revolve in the contrary direction from the central shaft upon which the differential is placed, whereas in the more modern motions none of the wheels revolve against the main shaft. It is claimed that the net result of these arrangements is to reduce the work and improve the action of the cone belt, so as to obtain more perfect winding-on with reduced wear of belt.

The first devised of the modern differential motions was Curtis and Rhodes', and although it dates back to the year 1882, it is yet probably the most used of any of the differentials, since three or four of the leading English makers have adapted it to their frames. For this reason we propose to describe this particular motion as made by Messrs. Hetherington. We refer now to Fig. 76. Referring to the foregoing sketch, and starting with the cone wheel, i.e. the wheel which is driven from the bottom cone drum, some of the wheels are varied in size for different makes of frame, but in this case the cone wheel is fitted on one end of a long sleeve, and at the inside end of the same sleeve is fitted a 23's wheel, which gears into a 35's attached to that portion of the differential box which is definitely fixed on the long driving shaft. The long sleeve revolves loosely upon the main driving shaft, and usually differs more or less in speed therefrom, but the two always revolve in the same direction. (See also Fig. 84.)

On the same boss as the 35 is a 20's spur wheel which gears into and helps to drive a second stud wheel varying in size from 23 to 27 teeth, as shown in the two side views. On the end of same shaft as the change wheel is a 14's wheel, gearing with and driving a 92's internal wheel B, running loosely on the main shaft. On the boss of the 92's wheel is carried the bobbin wheel as shown, this being the first of the train of wheels, to which is given the name of the "Swing." In actual working the wheel and the bobbin wheel obtain motion from two different sources, viz.: (1) Because the portion of the casing is fixed to the main shaft, the whole of the stud wheels, the internal wheel, and the bobbin wheel are taken round at the same speed as the main shaft, owing to the clutch action set up between the 14's and 92's wheels, and providing also the 23's cone or sleeve wheel is driven round at the same speed as the long main shaft. (2) In actual practice this equal speed is interfered with and varied by the 23's sleeve wheel having a more or less differing speed from the main shaft. In this case the value of the train of wheels is as given below :—

$$\frac{23 \times 20 \times 14}{35 \times 23 \times 92} = \frac{1}{11\frac{1}{2}}.$$

From this we obtain the following law, assuming the revolutions of the 23's sleeve wheel to be fewer than the revolutions of main shaft :—

Rule.—The revolutions of bobbin wheel and internal wheel = the revolutions of the main shaft, minus one revolution for every $11\frac{1}{2}$ revolutions that the cone wheel makes, fewer than the revolutions of main shaft.

Example.—Cone wheel revolutions 277, and driving shaft revolutions 300.

(*a*) 300 − 277 = 23
(*b*) 23 ÷ $11\frac{1}{2}$ = 2
(*c*) 300 − 2 = 298 revolutions of internal wheel.

Sizes of Wheel in Differential Motions.

The writer was asked to explain why the wheel purchase in some differential motions was so much greater than in others; or in other words, why is the first bobbin wheel in some motions one-fifth greater than the first spindle wheel, while in some other motions the difference is only about one-thirteenth or so. Furthermore, what in your opinion is the best proportion? It is, of course, well known to our readers that the first bobbin wheel in all the new differential motions for fly-frames is of larger size than the first spindle wheel in order to obtain the initial excess or winding-on speed of the bobbin directly from difference in wheel size instead of by making the bobbin wheel revolve more quickly than the spindle wheel, as in Houldsworth's motion. It appears to the writer that the true way to approach this problem is by first finding out how many excess bobbin revolutions are required for empty bobbins.

We may, for example, assume the speed of front roller to be 120 to 130 revolutions per minute, use long collar bobbins, and have them to be $1\frac{1}{4}$-inch diameter. It need hardly be said that these dimensions vary with different firms and on the slubber as compared with the roving frame; but they are near enough to actual mill conditions to answer our purpose under above conditions of say 120 excess, the empty bobbins must make 120 revolutions more than the spindle, and if we take the spindle speed at 1,080, we require an initial bobbin speed of 1,200. Now the excess revolutions of bobbin will be one-tenth of the total revolutions, so that to produce conditions which require absolutely no axial rotation of the internal wheels of the differential—in our opinion very good conditions indeed—we should want the bobbin wheel to be one-tenth larger in size than the spindle wheel. Cases from actual

practice could be found requiring both a larger and a smaller difference than the foregoing, and we are scarcely prepared to advocate the use of a change wheel in this connection, so that absolutely accurate conditions in this respect could be obtained in each case. For all that, there are many more unlikely things than that this could be done with advantage. Such motions as the Howarth and Fallow's, in which the spindle wheel contains 56 teeth and the bobbin wheel 63 teeth, or a difference of one-ninth part, appear to give satisfactory working conditions in the particular feature just discussed.

Although there are yet some advocates for the use of Houldsworth's differential motion, none of these could deny that the initial speed of the planet wheels or carriers in that motion have a comparatively high speed for empty bobbins—or, indeed, at all parts of the set—whereas, in the new motions very little axial rotation is

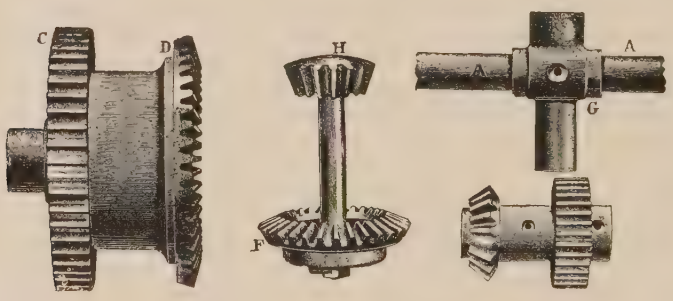


Fig. 77.—Howard & Bullough's differential motion.

ever attained, and practically none at the start of the set of bobbins. Furthermore, we should be surprised to find that anyone did not concede this to be an excellent feature in regard to the new motions. It is scarcely fair, however, to compare the results from a newly constructed and applied example of the later differentials with the results from a Houldsworth's motion after the latter has been working a score or more years, although this has often been done.

Howard & Bullough's Motion.

On the main shaft A (Fig. 77) is cast a boss or cross piece G, for the reception of, and to form a bearing for, the small cross shaft carrying the bevel wheels F, H. Loose on the shaft A is the bell, or, as it is sometimes called, the socket wheel C, which through its connections drives the bobbins. Attached to the wheel C is the bevel wheel D. Beyond the cross shaft, and loose upon the main shaft, is the wheel B, in connection with the lower cone

drum ; upon the extended boss of this wheel is cast the bevel wheel E, which gears into the bevel F. These constitute the parts of the new arrangement, the action of which is as follows : The shaft A revolves round, carrying the boss G, and the cross shaft around with it. If no disturbing factor interfered all the wheels geared together would, as we have also seen in the old arrangement, revolve together, and no winding would take place, as the speed of the bobbins would be the same as that of the spindles. In this case, however, it is necessary to note that the revolutions of the various wheels are all in one direction, and thus entail little expenditure of power beyond that required to overcome the inertia of the various parts of the machine and to maintain them in motion. It will thus be seen that the chief defect of the old arrangement is much diminished, viz. the great waste of power and the strain upon the working parts, and especially upon the cone strap. We now, however, want the winding to be performed, and in order to do this the bobbins must revolve as before, faster than the spindles. As in the previous case, the differential power is obtained from the cone drums, the bottom one of which through its connections drives the wheel B, which through its attached bevel E, working into the bevel F, on the cross shaft by means of the small bevel H, on its opposite extremity, accelerates through the bevel wheel D, the bell wheel C driving the bobbins. This acceleration is to the extent of the motion it drives from the

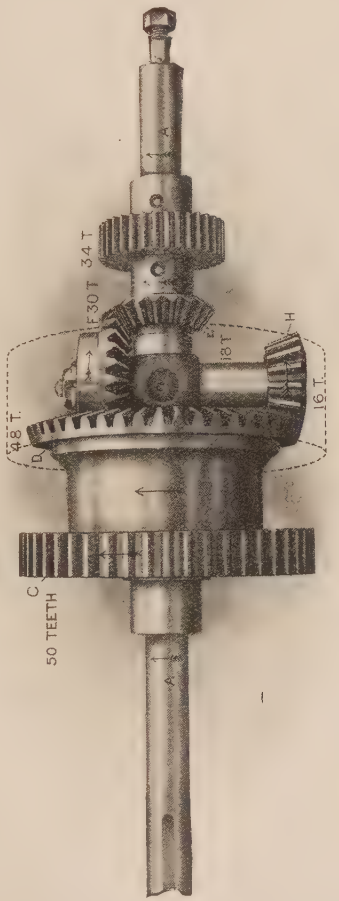


Fig. 78.—Tweedale & Smalley's motion.

cones. With the commencement of a set, of course, the bobbin starts at its maximum rate of revolution, whilst its rate is diminished by the shifting of the cone strap in the usual way. It will be seen that in this arrangement the revolution of the shaft A, becomes a help to the cone strap instead of a hindrance and an obstacle, as in the older form. This motion was invented by Mr. Tweedale.

Tweedale & Smalley's motion is shown in Fig. 78.

Calculation on Tweedale's Motion. (Figs. 78-79.)

It may be said that if the cone wheel B went just the same speed as the shaft, the cross shaft bevels H, F would have no axial motion.

The wheels H, F have their maximum axial motion when the cone wheel is stopped, owing to the cone belt being slackened for doffing or other purposes.

When working there are three distinct actions taking place: (1) H acts as a clutch with D, and endeavours to take D round

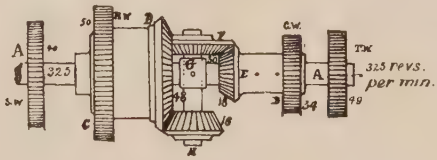


Fig. 79.

this way as fast as the shaft. (2) F rolls round E, and in this way the cross bevels H, F are made to rotate on their own axis. (3) The cone wheel B, E in its revolution, also endeavours to revolve the cross bevels and shaft, but in the opposite direction to that obtained from the direct rotation of the pulley shaft. The second motion goes to negative the first, the third or cone motion goes to negative the second, so that the first and third motions assist each other

$$\frac{S, W}{B, W} = \frac{40}{50} = \frac{4}{5}$$

or a difference of $\frac{1}{5}$ between the two.

This is the same proportion as between the carrier wheels.

$$\therefore \frac{E \times H}{F \times D} = \frac{18 \times 16}{30 \times 48} = \frac{1}{5}.$$

To find the revolutions per minute of bobbin wheel it is necessary to take $\frac{4}{5}$ of the main shaft speed plus $\frac{1}{5}$ the revolutions of the cone driven wheel in order to find the revolutions of the resultant wheel of the motion C, D. Be sure to measure cone diameters at

correct starting-point, at centre of initial part of cone belt, and plus one belt diameter to get revolutions of bobbin wheel. From bobbin wheel C, D to bobbin is a plain calculation. Some allow a slight percentage for cone belt slip.

Dobson's rule is $\frac{8}{9}$ of shaft speed plus $\frac{1}{9}$ of cone wheel speed to find revolutions of resultant wheel of differential

In Tweedale's motion (1) If the cone wheel revolves faster than the shaft then we may take it that the revolutions of B, W, would equal those of the pulley shaft, plus one for every five revolutions gained by the cone wheel on the shaft.

(2) If the cone wheel revolves slower than the main shaft, then from the speed of the shaft, subtract one for every five lost by the cone wheel.

Assume frame shaft to make 325 r.p.m. and the cone driven wheel at one time 0, and another time 380.

Find in each case the resultant revolutions of bobbin wheel C, D.

(1) $$325 - 0 = 325$$

$$\frac{325}{5} = 65 \text{ and } 325 - 65 = 260.$$

(2) $$380 - 325 = 25$$

$$\frac{55}{5} = 11 \text{ and } 325 + 11 = 336.$$

See end of this Chapter for other differentials.

Yarn on Roving Frames. Compound Twist Wheels. (See Fig. 71.)

There is often a certain amount of yarn spun on the bobbin and fly-frame to suit special requirements. Limited production due to limited spindle speed is an impediment to very extended adoption of this procedure. During the war some firms spun large quantities of yarn on the roving frame and kept many mules stopped owing to the difficulty of obtaining minders and piecers. A most excellent, silky looking, round yarn can be spun on the roving frame, well suited for bleaching, dyeing, and mercerising.

The ordinary single twist carrier between the twist wheel and top cone shaft in such cases may be changed for a double wheel, and it is also quite possible to put a compound wheel on the top cone shaft. In this way almost any desired range of twist per inch may be obtained, using small driving and large driven wheels for increased twist per inch and the opposite when a very small amount of twist is required.

Properly drafted yarn is usually spun on the roving frame with all the usual winding and building motions, and good bobbins are

thus produced. Very uniformly twisted, soft, hosiery or stocking yarn may be spun in this way.

The author has, however, spun coarse strong yarns on the rover, and also used the roving frame as a yarn doubling machine, without using any differential winding motion, but using the cone drums to drive the lifter. The skew bevels for the bobbins were all put out of gear, the swing and differential were disconnected, and the bobbins were pulled round by the strength and pull of the yarn after the understood style of the flyer throstle.

In any properly finished scheme of this kind flyer to lead flyers, with the presser following instead of preceding the flyer leg, should be used, but in above case satisfactory results were obtained by using the bobbin leading paddles, and the yarn swung back to pull round at the bobbin.

Drag was obtained by using strong banding threaded in and out and partially round the bobbin bevels over the lifter boards or top casings, and a weight hung at the end of the string. Such a device restricts occasional racing round of bobbin bevels.

When a roving frame is used for coarse condenser spinning as in the case of sponge cloth yarn, or for yarn doubling purposes, only the front top line of rollers may be used and suitably weighted.

Very superior, coarse, strong, doubled threads may be produced in this manner, suitable for such purposes as heald yarn and spindle banding.

For the most part, however, this roving frame spinning and doubling of yarn may be regarded more in the light of an emergency procedure, rather than to be definitely advocated in place of the well-established spinning and doubling machines. As stated, limited production due to low spindle speed is a serious obstacle for the most part, the ordinary flyer being a great hindrance to high speeds.

The author has seen examples of slubbing and intermediate frames in which the thick product has compelled the use of star wheels containing only ten teeth; each half tooth change permitted $\frac{5}{8}''$ cone belt side travel, and needed extra weight to pull the long rack forward.

Empty Bobbins.

Strength, combined with lightness, a good fit on the spindles, yet neither so tight as to need forcing on, nor so slack as to vibrate, well seasoned timber, and well applied hoops or rings; these are bobbin requirements. About a dozen empty bobbins per roving frame spindle is a good working basis, at about 20 lb. per 100 bobbins. Short collar bobbins are of smaller diameter than long ones owing to never passing over the collars.

Calculations for Slubbing, Intermediate, and Roving Frames (Hetherington).

General Formulæ :—

$$\left.\begin{matrix}\text{Revs. of}\\ \text{driving}\\ \text{shaft}\end{matrix}\right\} = \frac{\text{Revs. of main shaft} \times \text{diam. of pulley on same}}{\text{diam. of pulley on frame}}.$$

$$\text{Revs. of spindles} = \frac{\text{revs. of driving shaft} \times \text{wheel on same} \times 50}{\text{wheel on spindle shaft} \times 25}.$$

$$\left.\begin{matrix}\text{Turns of spindle for one}\\ \text{of driving shaft}\end{matrix}\right\} = \frac{\text{wheel on driving shaft} \times 50}{\text{wheel on spindle shaft} \times 25}.$$

$$\text{Revs. of front roller} = \frac{\text{revs. of driving shaft} \times \text{twist wheel} \times \text{wheel on top cone shaft end}}{\text{top cone wheel} \times \text{wheel on front roller}}.$$

$$\text{Inches delivered by front roller for one turn of driving shaft} = \frac{\text{twist wheel} \times \text{wheel on cone shaft end} \times 31416 \times \text{dia. of front roller}}{\text{top cone wheel} \times \text{wheel on front roller}}.$$

$$\text{Turns per inch} = \frac{\text{revs. of spindles per min.}}{\text{inches delivered per min.}}$$

$$\left.\begin{matrix}\text{Twist wheel and}\\ \text{Lifter wheel}\end{matrix}\right\} = \frac{\text{square root of present counts} \times \text{wheel on}}{\text{square root of required counts}}.$$

$$\text{Draft wheel} = \frac{\text{present counts} \times \text{wheel on}}{\text{required counts}}.$$

$$\text{Ratchet wheel} = \frac{\text{square root of required counts} \times \text{wheel on}}{\text{square root of present counts}}.$$

$$\text{Rack Wheel} = \frac{\text{square root of required counts} \times \text{wheel on}}{\text{square root of present counts}}.$$

$$\text{Counts or hank roving} = \frac{8\frac{1}{3} \times \text{length wrapped in yards}}{\text{weight of above length in grains}}.$$

$$\text{Weight per yard of roving in grains} = \frac{8\frac{1}{3}}{\text{hank roving}}.$$

$$\text{Inches delivered} = \frac{\text{revs. of spindles}}{\text{turns per inch}}.$$

Variation in Bobbin Revolutions at each Lifter Reversal.

On all bobbin and fly-frames spindles and bobbins always revolve in the same direction as each other but never at the same speed. Spindle revolutions are constant in any one case, but bobbin revolutions are always varying.

In all cases winding-on is accomplished by having a difference in rate of revolutions between bobbin and spindle.

Nearly all bobbin and fly-frames now have bobbin lead in which the bobbins always revolve more quickly than the spindles, the maximum difference being for empty bobbins, this difference in revolutions gradually becoming reduced as the bobbin increases in diameter, so that the winding rate shall remain equal all the time. The greater the diameter of bobbin the fewer the excess or winding revolutions needed.

Distinctive Points.

1. Formerly flyer lead was much in favour but was condemned soon before 1890 because of two evils.

(*a*) A broken end, especially on slubbers, often unroved somewhat and lashed amongst other ends causing waste and stoppage.

(*b*) Every time a frame was set on there was a slight tendency for the ends of cotton to be strained owing to backlash in eight or nine bobbin wheels being greater than in five spindle wheels.

2. With flyer lead the bobbins increased in speed as their diameter increased, in order to diminish the "difference" in revolutions between bobbin and spindle.

3. A full bobbin even in bobbin lead and fewer revolutions has approximately three times the surface speed of an empty one.

4. About 1910, and again in 1922, there was great controversy as to whether the spindle or bobbin put in the twist, most people favouring the spindle.

Various Calculations.

Q. How many hanks and pounds per spindle can be produced from the following: Revolutions of spindle, 650; turns of spindle for one of front roller, $5\frac{1}{2}$; diameter of front roller, $1\frac{1}{4}$; working hours of frame, 48; hank roving, $3\frac{1}{2}$?

A. (1) $\dfrac{650}{5{\cdot}5} = 11{\cdot}81$ revolutions of front roller.

(2) $\dfrac{11{\cdot}81 \times 5 \times 22 \times 60 \times 48}{4 \times 7 \times 12 \times 3 \times 840} = 44{\cdot}3$ hanks per spindle.

(3) $\dfrac{44{\cdot}3}{3{\cdot}5} = 12{\cdot}65$ lb. per spindle.

Q. What twist wheel would be required to give five turns of spindle to one of front roller from the following: Driving

wheel, 54; outside spindle shaft wheel, 54; skew gear wheel, 50; wheel on spindle, 26 teeth; top cone drum inside wheel, 30 teeth; top cone drum outside wheel, 40 teeth; front roller wheel, 115 teeth?

A. (1) $\frac{1 \times 54 \times 50}{54 \times 26} = 1{\cdot}92$ revolutions of spindle to one of frame shaft.

(2) For five revolutions of spindle we get one revolution of front roller, what revolutions shall we get of front roller for 1·92 of spindle?

$\frac{1{\cdot}92 \times 1}{5} = {\cdot}384$ revolutions of front roller to one of frame shaft.

We have now the particulars for a final speed calculation.

(3) $\frac{{\cdot}384 \times 115 \times 30}{40 \times 1} = 33{\cdot}12$ twist wheel.

Q. A mill working Egyptian cotton and spinning 60's twist contains 50 mules of 1,020 spindles each, and produces 19,125 lb. of yarn in a week of $56\frac{1}{2}$ hours. The slubbing frame produces 19,800 lb., and each slubbing spindle produces 50 hanks of 1-hank roving. The intermediate frames produce 19,650 lb., each spindle producing 48 hanks of 3-hank roving. The roving frames produce 19,500 lb., each spindle producing 39 hanks of 11-hank roving. (1) How many frame spindles of each sort are there in the mill? (2) What is the draft in the frames? (3) How many hanks per spindle are these mules doing?

Note.—The slubbers are supplied with a ·20-hank sliver from the draw-frame.

1. *Spindles required :—*

Slubbing = 19,800 ÷ 50 = 396 spindles.

Intermediate = 48 ÷ 3 = 16 lb. per spindle,

and 19,650 ÷ 16 = 1228 spindles.

Roving frame = 39 ÷ 11 = 3·54 lb. per spindle

and 19,500 ÷ 3·54 = 5508 roving spindles.

2. *Drafts.*—Slubbing frame draft = 1 ÷ ·2 = 5 draft.

Intermediate frame draft = $\frac{3 \times 2}{1} = 6$ draft.

$$\text{Roving frame draft} = \frac{11 \times 2}{3} = 7\cdot\dot{3} \text{ draft.}$$

$$\text{Mule draft} = \frac{60 \times 2}{11} = 10\cdot90 \text{ draft.}$$

3. *Mule hanks* per spindle $= \frac{19{,}125 \times 60}{50 \times 1020} = 22\frac{1}{2}$ hanks.

Roller Traverse Motions.

We are always hearing of or seeing something more or less new in regard to roller traverse motions, and this has always been the case since the writer knew anything of cotton spinning. A new fashion was started with variable roller traverse motions and shortly after there were several patented motions on the market for giving a variable traverse of one kind or another to the cotton ends or strands fed to fly-frames, mules, and ring-frames. There is much to be said for variable traverse motions, and they came to stop; several well-known examples are in extensive use at the present time. Mention may be made for example of Hurst & Fenton's champion traverse motion; Cook & Harrison's; Paley's, of Preston, as made by one or two firms; Tatham's duplex traverse motion; Dronsfield's; Coulthard's.

Simple Cam Traverse.

In spite, however, of all the numerous array of special traverse motions, it would still appear that the plain uniform traverse action is appreciated by most people and without doubt it possesses advantages of its own. For example, it is so cheap, simple, easily understood and adjusted, and so little calculated to go wrong in its working that many people consider these features to outweigh the advantages of the more ambitious traverse motions, which are all of a more compound and more complicated construction.

The specific purpose of a roller traverse motion is, of course, the prevention of channels or grooves from being worn round the peripheries of the leather-covered rollers by the cotton always working on one portion of leather. Wearing of leather is seldom if ever absolutely prevented, but it may be reduced to a minimum by the use of a traverse motion, which is always distributing the wear and work of the cotton strand along a certain proportion of the length of the roller. This specific object is attained by even the cheapest and simplest forms of roller traverse motion, and we don't think anyone would dream of doing without some form of such motion wherever leather-covered rollers are used, although motions could be adjusted better and kept in order better than they are.

Reversing Point of Traverse Motion.

While granting the usefulness of the simple heart cam traverse motion, it has always had the great weakness of slow reversing and extra wear of leather at the point of reversal. Most of the variable traverse motions provide a remedy for this by adding mechanism which continually alters the point of reversal. For example, in some cases the extent of the traverse is continually varied from a minimum to a maximum traverse; i.e. the traverse at one time only moves the cotton over a very small portion of the roller length, then the traverse lengthens and lengthens until the maximum has been attained, after which the shortening takes place. It might possibly take ninety minutes or so to vary from shortest to longest traverse and back again, and the point of reversal or changing of the traverse is always moving about. This moving about of the reversing point is undoubtedly attained in the manner described; but formerly discussion took place on the question of this traverse always passing the central point on the leather, however short or long the traverse happened to be. It was argued that this must give unequal wear of the leather. The timings vary.

Other makes of variable traverse obtain the movable reversal point in a totally different manner from the above. The extent of traverse is always kept uniform, but is very small, and the whole of the traverse is being slowly but continuously moved backwards and forwards along the working length of leather covered roller.

Crank Traverse Motions.

Attention has been given to another method of remedying the defects caused by the slow reversal of an ordinary roller traverse motion. The crank roller traverse motion—an old enough idea—has been revived, with the addition of contrivances designed to overcome the defects of the dead centres of the crank. Of this type is the now well-known Dronsfield roller traverse motion, which was first devised and applied at the Musgrave Spinning Co., of Bolton.

Thompson's roller traverse is also a crank traverse motion, with the slow dead centre defect overcome.

The device may be briefly described as follows: A worm wheel receives motion from a worm on one of the draft rollers in the usual manner. Cast with the worm wheel is an elliptical wheel, i.e. of an elongated shape, somewhat like an egg. The first elliptical wheel gears with and drives a second one of the same kind, and carried by a different stud. The large part of the driving elliptical wheel gears into the small part of the driven elliptical at one moment, while the next moment we have the opposite effect of a small driving and large driven wheel. The crank stud is adjustably

screwed to the flange of the driven elliptical wheel, and the traverse motion rod is linked loosely on this stud.

The rotation of the worm wheel from the draft roller is conveyed by the elliptical wheels to the crank stud. When the crank is passing its dead centre, and an ordinary crank would give a practical stoppage of the traverse at the reversing point, the first elliptical wheel has its largest diameter acting on the smallest diameter of the second elliptical, and this gives a comparatively rapid rotation to the crank so that the latter passes the dead centre so quickly as to give no more dwell of the cotton at the reversing point than at any other. On the other hand when an ordinary crank would be giving too quick a central traverse of the rovings, the elliptical wheels give the effect of a small driving and large driven wheel, and the traverse is kept at a sufficiently slow and uniform speed.

It is the combination of crank, worm wheel, and elliptical wheel in a particular manner, to give a particular effect, which forms this traverse motion. There can be no patent for elliptical wheels alone in connection with roller traverse motions. The present writer personally saw elliptical wheels working at the Deane Mills of Messrs. Poole, in Bolton, in 1904.

There is a distinct connection between the principles involved in the traverse motions of quick traverse winding frames, the traverse motions of card grinding rollers, and roller traverse motions, so that anyone making a special study of the reciprocating principle may find it advantageous to study and compare all these three special examples in a cotton mill.

The Duplex Traverse Motion.

This has an entirely different aim from any of the other motions specified above and we may explain its special purpose as follows :—

With other roller traverse motions, whether simple or compound, uniform or variable, crank or cam, there is a tendency to develop uneven weighting of the cotton in passing through the rollers. Take an intermediate frame in which there is one thread per boss, or two per top roller, with middle dead weighting of this top front roller. When the traverse takes the cotton strands to one limit of the leather, one of the pair of cotton strands on the same roller is farthest from the central weight, while its companion thread is at its nearest point to the weight. When the traverse afterwards reaches the other limit, the greatest weight comes on the opposite thread of the two, and this effect is taking place continually. It has been argued that this feature develops more or less of uneven drafting, and hence the invention of Tatham's duplex traverse which has received a fair amount of adoption. With the duplex

traverse there are two separate traverse rods, separately actuated, each carrying half of the cotton ends. The action is such that each pair of threads come to the centre of the roller and move away equally and simultaneously.

Constant Numbers.

Constant numbers serve a useful purpose in the calculations of a cotton spinning mill. The use of constant numbers, and the fact that individual spinning mills being often restricted to well-known sorts for which lists of wheels are kept after being tested by experience, and so many other tables of reference being available, many mills of even large size not requiring many calculations; and above all accuracy rather than speed being essential in inside mill calculations, have always restricted very much adoption of the slide rule in spinning mill practice.

A "constant number" may be defined as a partly made calculation obtained from constant factors, and ready to be developed or fully worked when certain variable factors become known.

It is more often a "dividend" which may at any time be quickly divided by a newly stated factor so as to obtain a change wheel.

It may be, however, if required, one half of a multiplication calculation.

Whether it be twist, draft, shaper wheel, gain measuring motion, or other regular calculation, there are often machine particulars and data of weights and measures which remain constant, and may often be reduced to small dimensions by a partially worked calculation so as to form a constant number which can be quickly utilised when a hitherto unknown factor becomes fixed.

Example.—A dividend for change draft wheels is a number which, divided by any desired draft, will give the necessary change pinion; or divided by any change pinion will give the draft.

Again, a dividend for twist is a constant number, which, if divided by any desired turns per inch, will give the twist wheel to put on. If divided by any twist wheel, it will give the resultant twist per inch.

Fixed wheels for the most part, and frequent alterations in counts or twist, bring out the use of constants to best advantage.

Neither slide rule nor "constant" numbers are of much use to foremen in mills which do not often change counts, or who have so small a range that proved sets of wheels may be kept wired together.

Our remarks may first be illustrated by the change pinion for draft. It is well known that the front roller wheel, crown wheel, back roller wheel and diameter of back and front rollers are seldom varied as compared with the change pinion. When we have a

little leisure time therefore in the mill we can take the above five particulars and work out a draft calculation as far as it will go. For instance, we will assume the following particulars to be on a self-acting mule, bearing in mind that exactly the same kind of working will apply to the ring-frame, bobbin and fly-frames, some draw-frames, the carding engine, etc. :—

Wheel on front roller	18 teeth.
Wheel on back roller	54 ,,
Crown wheel	90 ,,
Diameter of front roller	1 inch.
Diameter of back roller	1 ,,

$$\frac{90 \times 54 \times 1}{18 \times 1} = 270 \text{ constant.}$$

To show now the practical utility of this constant: The number 270 is kept conveniently recorded, and if at any time we desire to find the roller draft we simply divide by the change pinion which happens to be on. Thus, if there be a 35 change pinion on, the draft will be found as follows:—

$$\frac{270}{35} = 7{\cdot}71.$$

If, on the other hand, we desire to find what draft a certain change pinion will give, we simply divide the constant by the change pinion. Thus, if there be a draft of 8 required, the change pinion necessary will be :—

$$\frac{270}{8} = 33{\cdot}75, \text{ or, say, } 34.$$

For getting the twist constant we should adopt substantially the same method, but the calculation is a much more complicated one. An excellent general rule was laid down in 1895 in Thornley's "Spinning Calculations," and the same rule applies to finding the twist constant, excepting that the twist wheel is left out of the calculation. The rule referred to is as follows: "Assume the speed of the central shaft of the machine to be one per minute, and by the rule for speeds find the revolutions of front roller per minute, and also of spindles per minute. Divide the inches delivered into revolutions of spindle per minute."

Example.—"On the tin roller of a ring-frame is a 40 wheel driving an 85 stud wheel; on the same stud is a 45 twist wheel, driving, by means of carriers, a 100 on front roller; diameter of front roller 1 inch, diameter of tin roller 10 inches, diameter of spindle warve $\frac{3}{4}$ inch. This calculation is worked out in parts as per above

rule, and then the parts are compounded into one operation as follows :—

$$\frac{1 \times 10 \times 4 \times 85 \times 100 \times 7}{3 \times 1 \times 40 \times 45 \times 22} = 20 \text{ turns per inch}$$

and the twist constant is found by simply leaving out of above calculation the 45 twist wheel, thus :—

$$\frac{1 \times 10 \times 4 \times 85 \times 100 \times 7}{3 \times 1 \times 40 \times 22} = 900 \text{ constant.}$$

If we desired to put in 25 turns per inch we would simply divide 900 by 25 and we obtain the required twist wheel. Thus :—

$$900 \div 25 = 36 \text{ twist wheel.}$$

On a similar basis any other constant can be determined and short proved rules established, which may help a mill hand when he is very busy.

Bad Cones on Bobbins.

See that none of the wheels concerned in driving the lifter from the cone drums to the rail itself are badly worn in the teeth or slack in the studs. Also see that these wheels are geared sufficiently deep. See that the catches and cradles and hanger bar of the change motion work freely enough, and have all parts of the change motion in good condition. Sometimes bobbins run off owing to the frame being stopped just at the change, or possibly owing to the winding being very slack. Odd bobbins are spoiled at the ends in various other ways. As to order of looking for the cause of the evil, this would depend on a number of circumstances, such as certain frames being given to going wrong in special places more than others. The character of the running off would help an overlooker, or he might have been previously doing some alterations or repairs that had led to the evil.

Suppose you were making a six-hank roving, and you had to change to a four-hank, in each case retaining the same lift, what changes would you make, and in what order?

A. Such an alteration as this is often made in one mill or another, and it is seldom indeed that in such a case the length of lift is varied. As a rule, the changes made would be practically confined to the following four wheels, and it would be of little or no importance in what order the changes were made :—

(1) Change pinion for draft. (2) Twist wheel. (3) Ratchet or rack wheel. (4) Small strike wheel or lifter wheel.

1. To find the change pinion for draft the following rule would be correct :—

$$\frac{6 \times \text{Present change wheel}}{4} = \text{C.P.}$$

2. Star or ratchet wheel—

$$\sqrt{\frac{\text{Present rack wheel squared} \times 4}{6}} = \text{R.W.}$$

3. Twist wheel—

$$\sqrt{\frac{\text{Present twist wheel squared} \times 6}{4}} = \text{T.W.}$$

4. Lifter wheel—

$$\sqrt{\frac{\text{Present lifter wheel squared} \times 6}{4}} = \text{L.W.}$$

A larger change pinion is applied to increase the speed of back roller sufficiently to reduce the counts, but the front roller speed is not affected. A larger twist wheel must be applied to speed up the rollers sufficiently to reduce the twist per inch, also speeding the cone drums and the winding to compensate for increased roller delivery.

Square root is used for twist calculations because twist per inch varies directly as the square root of the counts.

Square root is not used for drafts or draft wheels, because these vary in proportion to counts, either directly or inversely as the case may be. 20's yarn is twice as heavy as 40's for the same length and only contains half the length of 40's in 1 lb. weight.

But 40's yarn has not got twice as much twist per inch as 20's. This is due to the relation subsisting between areas, diameters, and weights of cylindrical bodies. Square root is used because the diameters of rovings and yarn vary inversely as the square roots of the counts.

The rack wheel is made less in order to quicken the lateral travel of the cone belt, while the lifter wheel is made larger in order to get the speed of first lifter traverse correct.

Fly-frames for long stapled cottons require greater distances between roller centres and will therefore stand to be of larger diameter and fewer revolutions.

Fig. 80 shows an ordinary building motion, to which is applied a weight-relieving device, often applied by Messrs. Howard & Bullough, who adopted it in their slubbing, intermediate, and roving frames. Note the application of an auxiliary arrangement which raises the tumbler weights alternately, and at the proper time, in order to relieve the hanger bar already referred to of any

strain whatever. By referring to the illustration it will be observed that a pendant A is attached to the under side of the two-bar slide B, which in turn is secured to the top rail in the usual manner. Upon this pendant are two adjustable stop pieces A^1 and A^2, between each of which an arm C passes. This arm swivels upon an independent centre stud, and forms a sort of cradle at D, the two extremities of which are notched to take in the two weight hooks E and E^1. Each weight hook is extended through eyes in the holding catches, F and F^1, and are both formed with stop

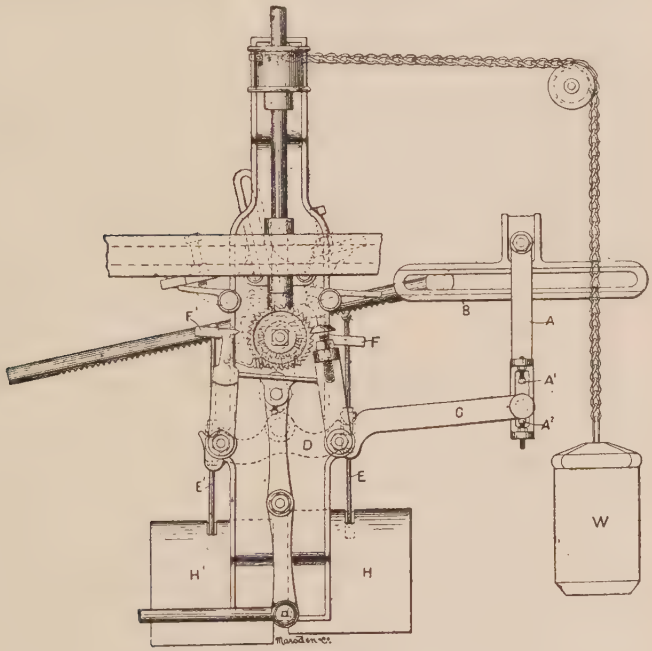


Fig. 80.

pieces, so that when descending they bring with them the catches named, their lower extremities being connected with the weights in the usual manner. A brief glance at the illustration will show that the upright rods suspending the tumbler weights are no longer connected with the upper cradle, but are worked independently by the rocking lever or arm C. In whichever direction the bobbin rail moves, the rocking lever is caused by the stops A^1 and A^2 to move with it, and thus raise one of the weights, while the opposite one will come into action just at the time the necessary changes in

the position of the cone strap are taking place. The author is of opinion that this is a step in the right direction.

Briefly, the action of this motion as hitherto applied is as follows: When the bobbin rail ascends it carries with it the two-bar slide and the hanger or radial bar. This latter turns the tumbler bracket partly round its centre until the adjusting screw relieves the catch bracket, to which is connected the strike shaft and wheels employed to give the reverse motion to the bobbin rail. In order to give a quick motion to these wheels, strong springs or heavy weights are used. These springs or weights also relieve the catches from the ratchet wheel so as to allow the drag weight to move the hanger bar and the cone strap to their necessary positions. In order to facilitate the lateral movement of the cone strap, especially in long frames, a heavy drag weight is used, and to enable the catch bracket to revolve freely round its axis at the time the change is being made the strain of one of the tumbler springs or weights has been taken up by the hanger bar. It will be observed that this strain is increased when the hanger bar has reached the angular position shown in sketch, which counteracts the action of the drag weight. That is, the tumbler weights or springs, to give the lateral motion to the strike shaft, retard the action of the drag weight and prevent the movement of the cone belt.

Hence, some time may be lost before the bobbins are driven at their usual speed, although this time will be very small under good conditions.

Speaking generally, any easing of strain on the short rack and change motion parts appears worthy of attention, on the part of carders and frame overlookers.

The Change Motion of a Fly-Frame.

The changing of the lifter traverse is part of the duty of the building motion or "box o' tricks." Taking one particular make of frame—others being much the same in principle—the central feature of the arrangement consists of two levers or cradles. The lower one of these is connected by a rod to the reversing bevels which drive the lifter, and during all the time of any one lifter traverse this lower cradle remains in one position, and holds a particular one of the reversing bevels in gear. The lower cradle is held in position by one of two horizontal screws against the pull of a spring or weight. When the lifter has moved through a sufficient space, a jack screw carried by the upper cradle or lever, and moved really by the lifter through the medium of the hanger bar, releases the horizontal lever, with the effect of permitting a sudden movement of the lower cradle, and consequently an allied

movement of the driven reversing bevels, so that the previously geared bevel is taken out of gear, and the companion reversing bevel is geared, so as to now drive the lifter in the opposite direction. It is through the medium of the building motion also that the cone belt is traversed laterally along the length of the cone drums, from the thick to the thin end of the upper or driving cone. Each sudden change of the lower cradle permits an escape of the star wheel for half a tooth, and the driving wheel of the long rack of the cone drum partakes of the same movement. The same with the short rack or hanger bar.

Coils too Far Apart or too Close.

If the coils of roving were too far apart it would be proof that the speed of the lifter was too quick. The cone end wheel would alter both winding rate and distance of coils, but there is a bevel or spur wheel more or less convenient on every frame for altering the lifter traverse speed only. A larger driving wheel would give wider coils.

It may be the strike bevel, or the bevel which drives the upright strike shaft, or a spur wheel at the frame end gearing.

Rollers.

For ordinary American cotton roller centres may be as follows :—

Slubber centre to centre front and middle $1\frac{1}{4}$ inch.
Intermediate ,, ,, ,, ,, ,, $1\frac{3}{16}$,,
Roving ,, ,, ,, ,, ,, $1\frac{1}{8}$,,

Sometimes the diameters of rollers prevent the settings from being as close as above, and then we may set as close as convenient without rubbing or interfering with any part.

The distance centre to centre of back and middle is always greater and is nothing like so important. Starting with the rover it may be $1\frac{1}{2}$ or $1\frac{5}{8}$ inch, plus $\frac{1}{8}$ for intermediate and $\frac{1}{4}$ for slubber.

Roller Stands and Cap Bars.

The following statement represents practice :—

Roller stands are bushed with brass for all lines of bottom rollers, and the slides and stands are milled for the brass bushes. In one case the bushes are secured in their places by copper keys so that when the brasses are worn a new set can be soon applied in exactly the same places.

Cap bars are milled all over and secured to separate steel fingers fixed to blocks on the cap bar shaft. A bracket is put on this shaft to act as a stop for the flat when turned up, when it is lifted up

to prevent any displacement of the cap bars. The brass bush has been the favourite for very many years for most machines having steel rollers.

When flats or top clearers are turned up it should not come in contact with the rovings, and there should be sufficient space to permit the rovings to be easily put through the eyes in the traverse bar.

Loading the Tapering Rod of the Fly-Frame.

The adjustment, operation, and effects of the hanger bar, tapering rod, diminishing rod (or whatever other name it may have) are much better understood at the present time than they formerly were. For example, it is now well understood that a short rod will give a keener taper to the bobbin than a long rod will give, other things being equal. At the same time we are of opinion that some practical men could beneficially devote a little time to this rod and its connections in order to obtain more perfect action. For example, it may pay to stop a frame the first layer after doffing, first at one end of the lifter traverse, and then at the other end, disconnect from the cone belt, and then note whether the tapering rod will slide backwards and forwards along the double slide, in a very free and easy manner. At this time the hanger bar is at its greatest angle away from the horizontal, and at the same time in a good many frames there is a distinct resistance applied to the rod or bar owing to its relieving one of the weights or springs from one side of the bottom cradle or catch cradle. We should like to impress the importance of this little idea upon practical men generally, because it may appreciably affect the quality of the cones formed on the ends of the bobbins, and every one knows this feature distinctly affects the working of the bobbins in this and the next processes. In some makes of frames the principle has been adopted of taking the strain, of relieving the weights or springs entirely away from the diminishing rod or poker bar, and placing the same more directly upon the lifter. It is the opinion of the writer that this idea—formerly devised by Mr. James Lucas, but so long ago that the patent rights have elapsed—is well worth the consideration of every one connected with the construction or practical manipulation of fly-frames.

We are well aware that in many frames with springs instead of dead weights, the spring is not only lifted clear of one side of the bottom cradle, but is also by an excellent cross connection made to pull down at the opposite side, and this is probably a desirable effect. The proof of the pudding is in the eating, and there can be no doubt that hundreds of frames are doing very nicely, although the strain of releasing the cradle spring or weight is made to devolve

on the hanger bar. At the same time we are opposed to this principle, and general results would probably be better if the principle were adopted in all fly-frames of releasing the spring or weight by some arrangement which left the hanger bar free from this work.

Bobbin Diameter Gauge.—On some machines, such as bobbin and fly-frames, it is of paramount importance to have equality in external diameter of empty bobbin. Naturally the gauges should be genuine instruments of precision. Good makers are just as well aware of this feature as are the spinners.

Messrs. Wilson Bros., for example, utilise, make, and recommend such gauges as shown in Fig. 81, in which there are three bobbin positions. This illustration belongs to them. (See also Fig. 72.)

The central one takes exactly correct bobbins. If a bobbin will fit in the upper stand it is too small in diameter or if unable to

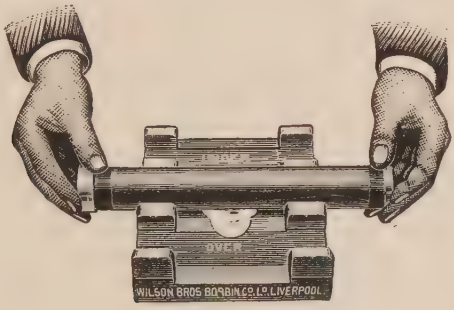


Fig.—81.

enter the lowest position it is too large in diameter. These positions will indicate very fine errors in diameter.

Surface Speeds of Bobbins.

The idea seems ingrained with many students and practical men that there is a fixed relation between the surface speed of the flyer leg and the bobbin, and that in bobbin leading the bobbin revolutions are reduced in order to maintain the fixed relation referred to. Let us repeat that the surface speed of a bobbin on any bobbin and fly-frame is usually somewhere about three times as great on a full bobbin as it is on an empty one, whereas the surface speed of the leg of the flyer always remains a constant factor for all diameters of the bobbin. Absolute surface speeds of flyer or bobbin do not count in the matter as regards winding-on, but we depend upon difference in surface speeds and revolutions to accomplish the winding-on satisfactorily. Naturally the student

replies, How can this be true if there is such a vast difference between surface speeds of empty and full bobbin, while that of the flyer leg remains constant? In answer we may say it is not a question of difference between flyer leg and surface of bobbin, but a question of difference between the surface of bobbin and surface speed of winding-on point of presser or exact point at which the roving passes from presser to bobbin. As the bobbin increases in diameter this exact point also moves away from the centre and gains increased surface speed in the same proportion as does the surface of bobbin. A roving frame bobbin might decrease in revolutions from possibly 1,120 for empty bobbin to about 1,040 or so for full bobbins, and when these speeds—which are only given as approximate—are multiplied by the respective circumferences we obtain a good idea of actual surface speeds of empty and full bobbins. The same reasoning applies to flyers without pressers.

Flyer Lead Frames.

A somewhat unusual proposition was put to the writer in the shape of two bobbins spun from beginning to end on the same frame, and with the cotton wound on the two bobbins in opposite directions. How was this effect attained? Naturally thoughts arose as to bevels being put on the wrong way about so as have a spindle or so revolving the opposite way, but this did not prove to be the case. Then it became a question of the bobbin being put on the spindle the wrong end up. Upon investigation, however, two factors seemed to contradict the feasibility of any such occurrence. In the first place there were no small bobbin bevel slots in the wrong end of the bobbin, and in the second place actually testing on the roving frame with bobbin leading appeared to demonstrate the impracticability of a decently built full bobbin being built in this particular manner. Although it was quite possible to wind small lengths of roving in this manner. Upon further reflection and testing, however, it was found possible to build a bobbin in this manner on a flyer lead frame, and this has apparently solved the problem. In a flyer lead frame the spindle is always faster than the bobbin, and is always, therefore, trying to help the bobbin on to its full working speed, whereas the spindle is no help to the bobbin in a bobbin leading frame, in regard to the excess revolutions required for winding-on. Moreover, in a flyer lead frame the cotton is wrapped round the bobbin by the flyer, and the cotton is always helping to turn the bobbin round, whereas in bobbin leading the bobbin draws the cotton upon itself and the cotton is resisting the revolution of the bobbin. This is a practical point which we have never before seen alluded to in print, and it certainly possesses features of interest both from a theoretical and a practical stand-

point. From practice and theory it would appear possible to build a bobbin all through in a flyer lead frame, when the bobbin is placed wrong end up and has no slots in this wrong end, although we may expect the roving to be defective in strength, uniformity, and twist.

Bobbin Twist v. *Spindle Twist.*

Writing in June, 1922, for months past numerous letters have been weekly appearing in the "Cotton Factory Times" referring to the question:—

"Does the bobbin or does the spindle put the twist in the roving at a bobbin and fly-frame?"

Sides have been taken by different letter-writers, and it appears nearly impracticable for one side to convince the other, even after a meeting and discussion in Manchester by nearly a score of disputants.

Most of the writers favour spindle or flyer twisting, but there are many adherents to "bobbin twist."

Models have been made to demonstrate one opinion or the other.

Much has been made of the fact that a coil wound on the bobbin may become a twist if unwound over one end—a feature which seldom or never appears in mill practice. It has not been made clear what practical benefit would result to the trade whichever side were able to finally prove its contentions.

Cap Bars.

Cap bars have always commanded attention — and rightly so—from practical men.

Great attention has been given to making them very smooth so that fly shall not accumulate on them; securing the nebs to the fingers in a very rigid manner, and yet to give every facility for adjustment.

Fig. 82 represents improvements effected by an eminent firm some years ago, and especially attending to the shape of the fingers.

Referring to the general view (Fig. 82), the small Figs. 1 and 2 show a back and side view respectively of the parts which form the bar as applied to a frame with four spindles in a box, Figs. 3, 4, 5, other details. The finger *a* was originally square, but in this case is pentagonal with five equal sides.

The lower portion of the hole in *b* is cut out V shape so that the finger always has a flat side on top for the adjustment screw *c*. Nebs similarly provided for.

Such an arrangement permits set-screws to be tightened without fo.cing nebs or fingers out of line.

First to last these arrangements go towards simplicity, rigidity, easy adjustment, freedom from twisted parts. Taper key *i* to hold bracket securely. Adjustment in any direction. Roller nebs free to move without also moving cap bars. Neb for front roller may remain untouched. Iron top clearer hinged on cap bar shaft which is not disturbed by moving bottom roller.

Cap-bar arrangements are worthy of attention on all machines in a cotton spinning mill.

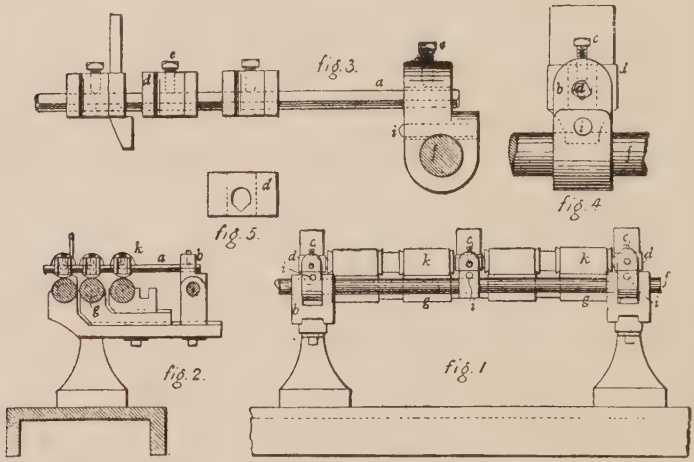


FIG. 82.

Extremely Coarse Slubbings.

In a case known to the writer very coarse counts of cotton were produced on the slubbing.

There were only ten teeth in the star wheel or builder wheel, and it was impracticable to regulate the winding rate to be sufficiently accurate. A tooth smaller ratchet wheel soon had the slubbings too slack, and yet without this the ends were too tight shortly after doffing. A tooth changed at the wheel on the vertical shaft for driving the long rack was found to give desired results. Regulation of cone belt at this position also gave better initial winding after doffing. One half tooth change at each lifter reversal represented so much long rack sliding that extra weight was proved to be advisable for giving the long rack movement. The utmost difficulty will be found in working slubbings which are very

irregular in counts, as it is impracticable to regulate the twist per inch and the rate of winding-on to be correct for widely varying cotton counts on different spindles at the same time, although bobbin draft has been known to vary from the common 1 per cent. up to as much as 15 to 20 per cent.

Twisting at the Mule.

A suggested method of finding the twist per inch at the spinning machines is to take two coloured yarns, each twice as fine as the usual yarn; run these through front rollers only for a matter of possibly 150 to 200 inches; afterwards the twist per inch may be counted by the aid of a glass. The author does not much recommend this method.

Backing-off and winding-on twist affect the twisting problem somewhat on a mule as well as slip of rim band. Placing the twist motion on the tin roller shaft, and disengaging it during backing-off and winding-on, help to produce full and more exact twist.

The Swing Frame.

The compensating swing of one well-known firm apparently accounted for the gaining and losing of the bobbin due to the "swing" train of wheels being epicyclic so that rolling contact affects driving contact.

The compensating swing, however, did not survive very long owing chiefly to increase in breakdown and greater difficulty in adjustment.

The rolling contact gain and loss is still with us, and only lately the author's attention has been drawn to two different slubbers in two different mills in which the variation was apparent.

In the first case there was real trouble in balancing the winding to accommodate very thick slubbing, so that the ends would not be too tight at one minute and too slack at another.

In the second case it was demonstrated that the cotton ends always went slack when the winding-on was approaching the top of the bobbin, and yet if the rack wheel were tightened one tooth the slubbings would be too tight elsewhere.

An alteration of a tooth on the large wheel that drives the long rack was effected, and a slightly altered setting of the long rack and of the half-tooth escape of rack wheel.

It would appear that the above is some argument in favour of chain drives, especially as chains have been vastly improved in make of recent years.

Twenty-five years ago the present author demonstrated that

this gaining and losing on a slubber could equal about two-fifths or more of a bobbin revolution at the beginning of a set of bobbins, in one full lifter traverse.

The gaining or losing varies in different positions of the lift. Scientific adjustment of centre of main driving shaft in relation to centre of path of lifter traverse may help somewhat, but fly-frames can hardly be considered very correct until some simple arrangement remedies the feature discussed.

Roving Frames.

Dr. Ure wrote in 1836 :—

"After the process of drawing the next operation is the making of a roving or thin sliver, which is very tenderly twisted. In the tube roving frame the twist is merely momentary.

"An incredible number of machines has been contrived, since the first elegant can-roving frame of Arkwright, for the purpose of performing this operation with precision and speed. By that frame the slivers, after passing through the drawing rollers, where they were considerably elongated, received a slight twist from the revolution of the tin cans into which the rovings fell, and were distributed round its interior surface in regular coils by the centrifugal force."

(The Jack-i'th'-box also received some favour, but shortly after Dr. Ure prepared his treatise the bobbin and fly-frame—based upon the flax or Saxony hand-wheel, and having its winding-on attended to by Houldsworth's differential motion of 1825—began to assume the dominant position which it retains unchallenged at the present time.)

"This beautiful machine has arrived at its present state of perfection through more numerous efforts of ingenuity, and by the co-operative agency of a greater number of individuals, than any other mechanism known in the cotton trade. The chief difficulty in these machines proceeded from the soft delicate nature of the roving, and the nicety required to wind it on at neither a faster nor a slower rate than the front roller pair sent it forth. This nicety was increased by the ever-varying circumference of the bobbin within the flyer, as well as by the changes occasionally required in the twist."

Houldsworth in 1826 obtained a patent for his "sun and planet" motion or differential winding motion, which Dr. Ure says "affords, perhaps, the most refined specimen of the automatic equating principle to be found in the whole compass of science and art."

Since 1884 several motions have combined to supersede Houldsworth's.

Pressers.

Ure says (1836) :—

"I made the following experiments at Mr. Orrell's factory on uncompressed and compressed bobbins :—

"1. The large bobbin of the first or coarse bobbin and fly-frame contained 14 ounces of roving applied by the spring presser.

"2. The same sized bobbin filled with uncompressed rovings only contained $7\frac{1}{2}$ ounces.

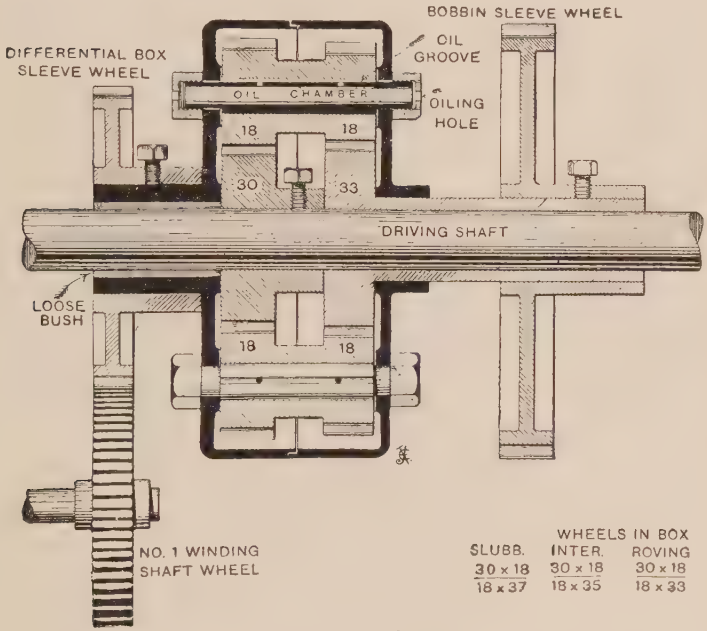


Fig. 83.

"3. The smaller bobbin of the second, or fine bobbin and fly-frame, contained 8 ounces of compressed roving.

"4. The same sized bobbin uncompressed only $2\frac{1}{2}$ ounces.

"A conical bobbin with compressed roving from the fine bobbin and fly-frame, will last in a mule five days, and in a throstle six, which is three times longer than the uncompressed bobbins will do.

"Since Houldsworth's motion was patented in 1826 and Ure's book was published in 1836 it is clear the presser dates almost to the first proved success of the bobbin and fly-frame. Double press flyers became largely adopted in the period 1860-70, but shortly

went out again owing to greater expense, a single presser giving all the advantage required, and flyers becoming unbalanced because of one of the two pressers of a pair getting damaged or strained.

"There are not very many flyers now working other than with single pressers, neither the double press nor the no-press method maintaining favour, except perhaps the latter for the finest rovings."

Messrs. Brookes and Doxey state as follows :—

(*Shaw's Motion.* See Figs. 83, 83A.)

"*Differential Motion.*—The motion we supply is either Brooks & Shaw's or Curtis & Rhodes' patent, for which we claim the following advantages :—

"1. The construction of the gearing in these boxes is such, that

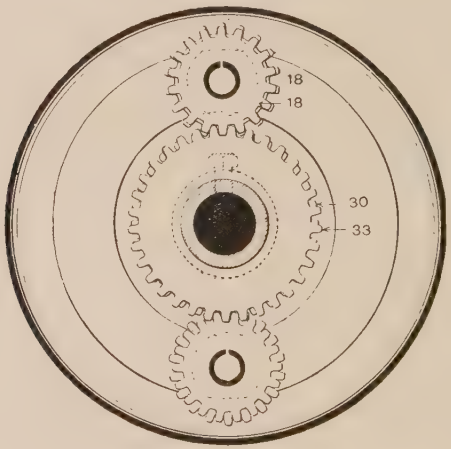


FIG. 83A.

it enables the cone belt to have much more control of the differential speed, thus reducing the strain on it and ensuring better winding.

"2. The driving shaft and bobbin driver run in the same direction, and thus reduce friction.

"3. The bobbins and spindles commence revolving exactly together.

"4. Less wear and tear than in any other motion.

"5. Simplicity and accessibility.

"The following description of the drawings, Figs. 83, 83A, will be useful in tracing through the gearing and construction of the Brook's & Shaw's motion as applied to a roving frame :—

"On the driving shaft, which receives its motion directly from the main belt, is fixed a spur wheel containing thirty teeth which

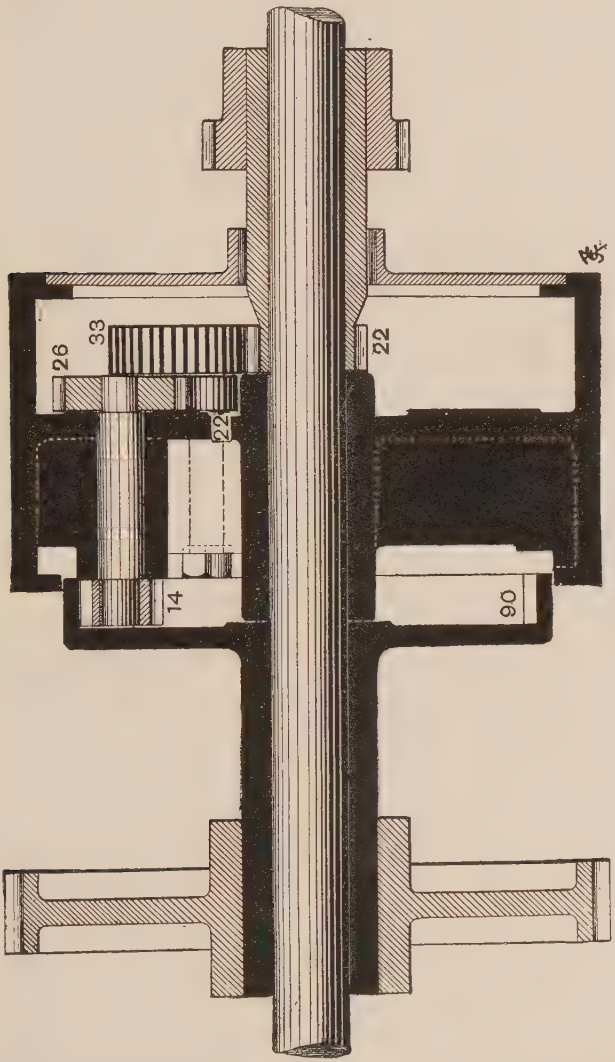


Fig. 84.—Rhodes' motion (made by Brooks & Doxey).

gears into a double carrier pinion, each pinion containing 18 teeth; these two pinions are cast together and are of course perfectly rigid;

they run on studs carried by two discs which run loose on the driving shaft, these discs being provided with flanges which meet and form an oil-tight joint. The studs are also bored through in order that the carrier pinions may be oiled from the outside; the casing and their outer ends are specially constructed so as to provide an oil reservoir, and also to prevent any oil being thrown off outside the casing. The smaller 18's pinion gears into a 33's long sleeve wheel which runs loose on the driving shaft; fixed on the end of this sleeve is a 66 bobbin sleeve wheel, by means of which the bobbins are driven. The carrier pinions are revolved round the 30's and 33's wheels at a speed which is governed by the cones."

If customers prefer, they may apply Rhodes' motion as per Fig. 84.

Rhodes' motion is now also made by several other machinists.

On the main shaft is a loose sleeve upon which is fixed a spur wheel containing twenty-two teeth, gearing into the 33's wheel attached to that portion of box which is fixed on driving shaft. On the boss of this 33's wheel is a 22's wheel gearing into a 26's, on the end of which is a 14's driving a 90's internal wheel which is loose on driving shaft. On the boss of the 90's wheel is carried a 60's bobbin driving wheel. From this description it will be seen that the range of gearing is such as to obtain practically a positive drive between the driving shaft and bobbin wheel (see Fig. 84).

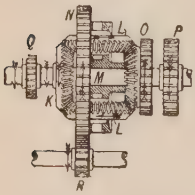


Fig. 85.—Holdsworth's differential motion.

A more complete descrption of Rhodes' motion has been previously given in this chapter in connection with Hetherington's frame. Also Howard & Bullough's or Tweedale's motion.

In Fig. 85 is shown Holdsworth's motion, invented about 1825 and yet to be found on some bobbin and fly-frames.

O is the resultant wheel of the motion and is equal in size to P, the first wheel for driving the spindles.

The bevel K is set screwed to the frame shaft, has therefore the same speed, is the chief driving wheel, and because the four bevels are of equal size gives frame shaft revolutions to the compound resultant O, but in the opposite direction from the shaft. O is the first wheel of the "swing" motion. The Jack wheel A drives the sun wheel N, this drive coming at a variable rate from the bottom cone drum.

For modern bobbin-lead frames the sun wheel revolves in same direction as resultant O and gives two extra revolutions to O for every one of itself. For flyer lead the sun wheel turns in same direction as frame shaft and takes two revolutions off O for every one of itself.

Cone Drums.—Uniform cones have at different times been tried on fly-frames by sceptical people, but always without success so long as a uniform "let-off" or long rack motion has been also used. The increase of $\frac{1}{4}$-inch diameter to an empty bobbin is a much greater *proportional* increase than an increase of $\frac{1}{4}$ inch to an almost full slubber bobbin of $5\frac{1}{2}$-inch diameter. Concave and convex cone drums give the required greater proportional increase at the beginning and lesser proportion for the larger bobbin diameters, but uniform or rectilinear cones fail to do this. The cone drums attend to the excess or winding-on revolutions of bobbin, and it was explained in the author's earlier treatises that if a 2-inch diameter bobbin required 200 r.p.m. from the lower cone, a 4-inch diameter would require 100 revolutions, whereas uniform cones would give 125.

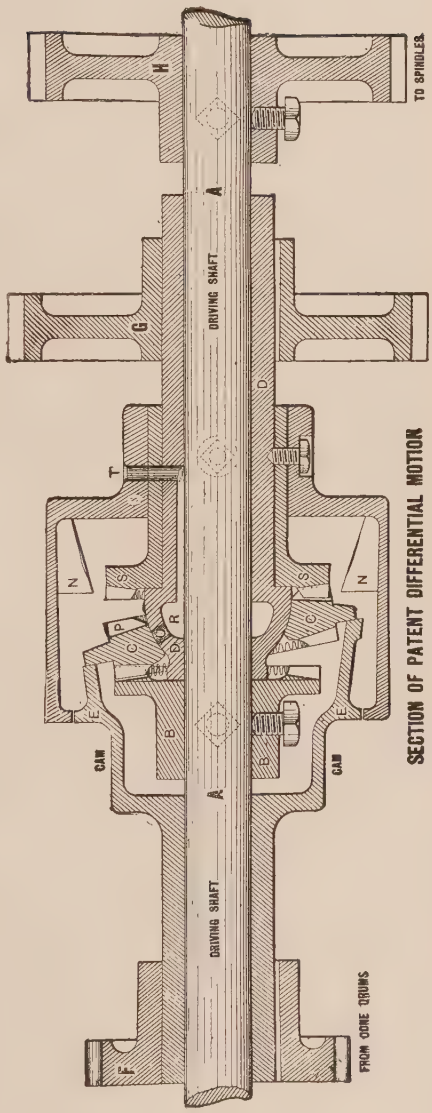


FIG. 86.—Dobson & Barlow.

Messrs. Dobson & Barlow's Differential Motion. (See Fig. 86.)

A Driving shaft.
B Bevel wheel fixed on shaft A.
C Oscillating bevel wheel, mounted on spherical bearing, and gearing into B on one side and into bevel wheel S on the other side.
D Spherical bearing with long collar running loosely in the same direction on shaft A.
E Cam with inclined surface, bearing against the rim of bevel wheel C, and driven from bottom cone through jack shaft and spur wheel F.
F Spur wheel mounted on boss of inclined cam E and driving same.
G Bobbin driving wheel, mounted on boss of spherical bearing D.
H Spindle driving wheel, secured to driving shaft and positively driven.
N Projections for distributing the oil.
P Teeth on oscillating bevel wheel C.
R Enlarged oil chamber.
S Bevel wheel fix d to spherical bearing and gearing with oscillating bevel wheel C.
T Oil inlet.
U Oil passage to spherical bearing.

The essential features of this differential motion are as follows:—

Its compactness; being self-contained and encased in a polished shell, which in outward appearance resembles an ordinary shaft coupling.

Good lubrication; the oil enters at T directly to the driving shaft, and after flowing into the chamber R, passes through U and lubricates the spherical bearing D and bevel wheel C. The oil also lubricates the inclined surface of E. The centrifugal action of the motion causes the oil to constantly circulate throughout the bearings while at work, and is equally distributed by means of the projections N.

The motion is protected from dirt by means of a casing and the cam E, which at the same time prevent the oil from flying outwards.

The gearing being thoroughly immersed in oil, little power is required to drive it.

(See also pages 296 to 303 for other differential motions.)

CHAPTER VII.

RING SPINNING.

Principles of Spinning Machines.

THE chief differences in spinning on the mule, flyer throstle, and ring-frame, are indicated below.

The mule is an intermittent spinner, first spinning and twisting the yarn, and then winding it on the cops as a separate process. On the other two machines the processes are continuous, drafting and twisting of the cotton taking place simultaneously with winding-on. Usually the mule yarn is wound either on the bare spindle or else on a small paper tube, whereas on the ring-frame it is generally deemed advisable to place the yarn on a wood or paper bobbin, and this is a special advantage of the mule in the case of pin-cop weft intended for direct use in the loom shuttle. The flyer throstle also requires a bobbin to put the yarn upon. The ring-frame is distinguished from the other machines by having inclined roller stands in order to allow the twist to run along the yarn to a more perfect degree. The flyer throstle is almost obsolete for cotton spinning, largely because the yarn has to pull a comparatively heavy bobbin round, and the use of a small flyer limits the spindle speed and restricts production. There is usually more draft in the ring-frame when spinning same counts of yarn from same back bobbin, because there is no carriage draft or "gain" in the ring-frame and nothing to prevent contraction of the yarn due to twist. The fly-frame performs its winding by the lagging behind of the bobbin; the ring-frame by the lagging behind of the traveller; the mule by the use of definite winding mechanism, including the quadrant and its companion parts

The Ring-Spinning Frame.

The simpler construction of the ring-spinning frame—as compared with the self-actor mule—is immediately apparent when we consider the important operations which occur in connection with spinning the thread, as distinct from winding it on the spindle or bobbin. In the mule, during spinning, we have the three fundamental operations of drafting by rollers, twisting by spindles, and

keeping the threads tight by a receding carriage, even to the extent often of carriage moving more quickly than rollers. Winding-on is a different and subsequent operation and—along with cop shaping—involves complicated mechanism which is entirely absent in the case of its great rival, the ring-frame. Certainly we have also on the ring-frame the twisting by spindles and the drafting by rollers, but there is no need for a receding carriage to keep the threads tight. Since the inauguration of the cotton-factory system by Arkwright, Crompton, and their contemporaries, there has been a ceaseless struggle for supremacy between the mule, or intermittent spinning machine, and the continuous system of spinning, as first represented by the flyer throstle, and during more recent years, by the ring-spinning frame. In countries like America, owing to such circumstances as greater trouble with respect to skilled labour for mules and the always strongly manifested tendency to adopt more automatic machinery for any purpose, the ring-frame has long been the more used machine by far. In England the mule has also been threatened with extinction at different times, but it yet remains far and away the more used machine of the two. It is the custom in some cases to state that this is true only of the finer numbers of yarns, such as are spun in the Bolton district, but really it is true also of the Oldham district, which is the chief centre of such counts of yarn as 20's to 40's from American cotton. Nor does the mule yield up its supremacy when we come to spin such coarse yarns as 6's to 15's, because in such cases the wonderful adaptability of the mule to extremes of counts and range of twist per inch, is very well brought out. A good deal of this supremacy of the mule is due to the splendid skill and intelligence of our minders, overlookers, managers, and machine makers.

After all this has been said, the fact remains that even in England there are very many ring-spinning concerns now successfully at work, and producing yarns which are apparently well suited to the requirements of many customers; and this in spite of the difficulty often experienced by our ring-spinning firms in obtaining sufficiently good cotton at a reasonable price.

Inclined Roller Stands.

The most distinctive feature about the draft rollers—and, indeed, one of the most distinctive features of the machine—consists in their sloping disposition towards the delivery. Very early in the history of the ring-frame it was found that the tendency for the thread to impinge against the thread guide, and still more, the tendency for the thread to rest on the front steel roller, prevented the twist from flowing as freely up to the bite of the roller as was desirable, with the result that for most yarns thread breakages

were often very excessive. A very great improvement was effected in this respect by inclining the roller stands downwards at the front so that the twist enters the cotton practically at the nip of the roller, or as soon as any strain is imposed upon it.

For extra hard twist yarn or crape yarn, it is possibly the best to have little or no inclination in the stands, although even in this case it is more usual to have the inclination.

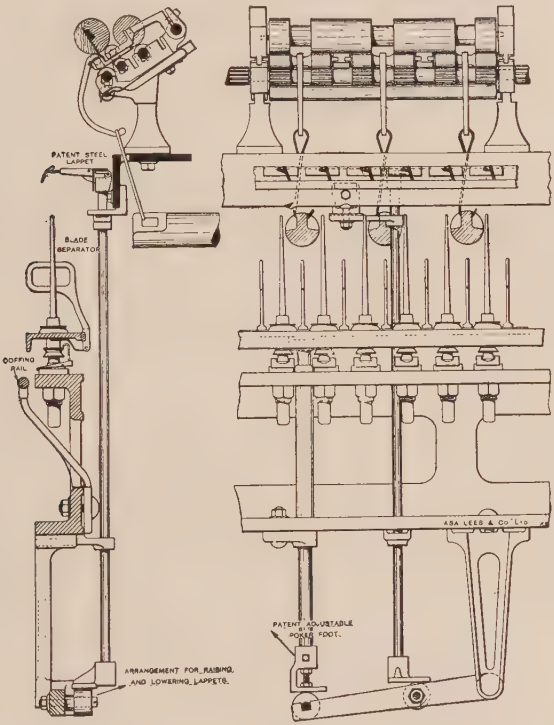


Fig. 87.

Recently, the writer spun some hard twist with an inclination of over 20°, and found it difficult to prevent crackers and snarls. With the extra hard twist there is not much fear of the threads breaking at the nip of roller, because there is sufficient twist for some of it to pass freely from spindle to roller, especially if the spindles are brought a little further forward.

A good deal of experimenting has been done in regard to different degrees of inclination, but it is very seldom that more

than 35° from the horizontal is exceeded, and even this amount is more particularly for very short staple cottons, such as Indian, or very soft twisted fine yarns.

One eminent firm of machine makers state they usually make the roller stands 24½° inclination for Egyptian and American cottons, while another equally eminent firm advise incline stands of 26° for all such average purposes. It is scarcely likely that 1 or 2° more or less will much affect the matter. For manner of weighting top rollers, inclination of rollers, anti-ballooning arrangement, poker connections, etc., the reader is referred to Fig. 87.

The Ring-Frame Creels.

There is no doubt the ring-frame ranks as one of the simplest in the mill. It comes within the same class as most winding frames in being a double-sided machine, it being quite easy to arrange gearing that will serve for both sides, with the creel most conveniently placed in the middle. The spindle space is invariably greater than that of a self-acting mule. For instance, take the fine mule twist gauge of 1¼ inch; we might have the ring-frame gauge of, say, double that, or, say, 2½ inches, so that the double-sided ring-frame of 2½-inch gauge requires the same creeling arrangements as the one-sided mule with 1¼-inch gauge. Broadly speaking, therefore, the creeling arrangements may be very much the same for the ring-frame and the mule, remembering preference may be given to the single creel in many cases on the mule, whereas the double creel is almost always the most convenient on the ring-frame. Example: For 60's twist on the ring-frame it would be quite necessary and quite convenient to use the double creel, but for 60's twist on the mule a single creel is usually preferred, although it compels the use of a creel of four heights, and may even necessitate the use of full bobbins and halves.

Little piecers sometimes need buffets or stools when creeling these high creels.

The Birkenhead type of creel appears to be exceedingly suitable to the ring-frame, and many people appear to use it, although it is somewhat more costly to make than the plain type of creel. In the Birkenhead type of creel a very deep but very narrow wood centre piece is used, and a small finger is screwed to this centre piece for the top end of each skewer, and another finger for the footstep of each skewer in the next higher row. By this means the top of the lower skewer very distinctly overlaps the foot of the higher skewer, with the final result that the creel height is kept within very reasonable limits, even when three rows of bobbins are used for double roving.

Naturally a low creel is of even greater importance on a ring-

frame than on a mule, owing to the large proportion of female labour employed in charge of ring-frames. We are not aware that four-height creels are ever required for the ring-frame, such as are in frequent use on fine spinning mules for double roving. For single roving on the ring-frame the choice lies between two-height creels and flat creels, while for double roving the choice for the ring-frame lies between two-height and three-height creels. The writer's experience of flat creels is not in their favour, and perhaps their chief advantage consists in allowing more light to pass over the creel tops in cases where the windows are behind the machinery.

In preparation spinning, using slubber bobbins in the mule creel, three rows of creel are used, with bobbins 4½ to 5-inch diameter.

Creel Ends and Spring Pieces.

Sometimes the creel ends of ring spinning or ring-doubling frames may be arranged with plain vertical rods for supporting the middle and top portions of the creels, while at other times substantial cast-iron frames are used for the creel ends. We should like to remark that the use of the cast-iron frame ends appears to stiffen and strengthen the whole of the creels very materially. The plain rods are, of course, used for the intermediate supports for the creels, and this is sufficiently good practice, but so far as rigidity goes we are bound to speak up for the cast-iron ends, after giving a test to both kinds. We are by no means certain it would not pay even on self-acting mules to have similar cast-iron framings for the creel ends, because some creels are much too shaky.

Touching also this question of rigidity, an improvement has been effected in some cases by using a greater number of samsons in the length of the frame, and at the same time making each samson or spring piece of a stronger pattern. Also at the same time some firms make the frame ends and the spring pieces with loose feet for adjustment to suit uneven floorings, so that each frame end and spring piece will rest in a firm manner. Moreover, there will be no danger of some of the supports being rendered useless by warping, shrinking, or accidental removal of their wood packings. The writer has observed an astonishingly large number of cases in which machines of various kinds have been troubled by the wood packings going wrong in one way or another. We are afraid that some fitters are a little careless in this matter of arranging the wood packings to the best advantage in the first instance. The writer is decidedly in favour of adjustable feet and—as far as possible—dispensing with wood packings.

In regard to the question of steadiness and rigidity, we may consider the supports for the rollers, and it is well for these to be

carried on strong angle beams well supported by the spring pieces. A ring-frame should also be well braced together by using specially constructed girder rails for carrying the spindles, ring rails, and lifting motion. To ensure these parts being always held in position the beams and girders are now sometimes steadily pinned to the spring pieces and frame ends, in addition to the usual boltings. The tendency towards high speeds of spindles and rollers makes it all the more necessary to pay attention to such points as have been discussed in the foregoing article.

Steel Creels.

During the last few years there appears to have been a growing tendency to use steel creels for ring spinning and ring-doubling frames, and the present writer was shown some of these during a visit to a machine shop. Somewhat increased cost may prove an obstacle to their extensive adoption, but they appear to add to the rigidity of the framing. The top board in such a case is made of thin sheet steel, and is exceedingly firm, besides being very smooth. The edges of this top board are conveniently turned up to prevent bobbins or anything else from rolling off. The bottom board may be an absolutely straight, smooth, thin sheet of steel, which can be wiped or cleaned in a most easy manner. In some cases the top board only is made of steel turned up at the edges, the bottom one being of smooth wood. If required, the middle supports for the bobbins or skewers may be either all wood, or wood with the Birkenhead iron fingers, or of angle iron lined with wood, so as to give the best combination for ensuring rigidity combined with lightly running skewers. Some prefer not to use the middle board on account of its tendency to collect dirt and fly. Holes are drilled in the angle iron through which the pot steps for the skewers are set. The experience of the writer is opposed to having skewers to rub against ironwork either at the tip or the foot of the skewer, and whether referring to ring-frames, mules, or bobbin and fly-frames. Apart from the question of rigidity, it may be said in favour of steel creels and top or bottom creel-boards, that they will not be liable to warp out of truth, or become soaked with oil. It is, of course, safer from fire risk than the ordinary wood creel, and affords another example of the increasing tendency towards the use of thin sheet steel in connection with cotton machinery. The all-metal or steel carriage for self-acting mules, and the semi-steel carriage, are of course other striking examples of the same tendency. Possibly the increased price of suitable timber may have some influence on this particular problem. The question has arisen as to whether glass or porcelain steps are to be preferred for the creels of mules and ring-frames, and all the

arguments do not appear to be in favour of either one or the other. Perhaps the glass steps give a little easier running, but it is necessary to guard against the evil of over-running. We are in favour of the practice of fixing at intervals in the length of the creels small rounded receptacles for holding a supply of travellers ready for renewals. Skewer pointing machines are available.

Creels and Skewers.

The question of creels is, of course, closely connected to that of skewers. Mr. Wood, of Bolton, was granted full letters patent on 26th October, 1911, for: "Improvements in creel spindles or skewers for machinery for preparing, spinning, and otherwise treating fibrous substances." It is well known that such skewers are usually all of wood, and the object of this device is the production of spindles or skewers of such a construction as will prevent warping, twisting, or bending of the same by heat or otherwise.

In one sample which we examined the wood or cylindrical portion of the skewer was arranged to have a centrally supporting tube or core of metal. When a tube is employed this could be on the outside of the spindle. The metal part is designed to act as a support for the wood part. Mr. Wood says: "When the spindle is hollow or otherwise, I make use of metal tips or extremities so the same may run more freely in their bearings. The base tip may be of glass or other hard substance, provided metal is found not to answer the purpose. Or in place of this base being made pointed to rest on its bearings, I may mount in an appropriate cavity formed at the base of said skewer a metal anti-friction ball, which will thus act as a bearing for same, or said anti-friction ball may be mounted within the opening within said spindle or skewer with a supplementary part extending through it, and out through said base or extremity to rest upon the bearings which support the same. These bearings may be of metal, porcelain, or other substance. They may be further provided with an anti-friction ball or balls."

Ring-Frame Calculations.

Assuming you are spinning 20's twist on a ring-frame, and you alter to 32's, what alterations will it be necessary to make?

The principal alterations would consist in changing the twist wheel, draft pinion, and builder wheel. The twist wheel would require a smaller wheel to reduce front roller speed, and to be altered as follows:—

$$\frac{\sqrt{20} \times \text{T.W.}}{\sqrt{32}}$$

The builder wheel would require a larger wheel to retard the building of the bobbins to be altered as below :—

$$\frac{\sqrt{32} \times \text{Builder W.}}{\sqrt{20}}$$

The change pinion would require to be reduced in size to increase the roller draft, the calculation being represented below :—

$$\frac{20 \times \text{Change Pn.}}{32}$$

The traveller would probably require to be made 4 or 5 counts finer for the 32's. In the case of a permanent alteration it is highly probable a finer hank roving would be used for the 32's.

Driving of Ring-Frames.

1. The half-crossed belt as used from a steam-driven line shaft with a line shaft 300 to 350 r.p.m., gives too much angle in the belt due to the large diameter of line-shaft drum, 24 to 34 inches.

The separate motor drive, with a motor speed of 700 to 900 r.p.m. has been in some favour for ring spinning and ring-doubling frames because of the motor speed being well adapted for direct coupling to the tin roller of equal speed. Ring-frame work is not spoiled by a prompt starting of machine.

Gallows pulley driving has been much favoured because of the long powerful belt obtainable.

Inability to alter the speed of tin rollers and spindles has been a serious defect in the separate motor drive, direct coupled on extended tin roller shaft.

A good modern method consists in the direct application of a motor on a top line or counter shaft which serves for a number of ring-frames, or if need be for one only. The pulleys can easily be changed for speed effects. Running this top shaft at about the same speed as the average tin roller speed, a half-crossed belt may be used in which only a small and good working angle of belt is needed because of top and bottom pulleys being nearly equal in size—say about 12 inches or so, as found on many combers and roving frames with steam driving.

Gallows Pulley Driving.

It is sometimes a little difficult to set the two gallows pulleys with the accuracy and special setting necessary to keep the belt always on the pulleys, and proper centring and judging of the pulleys is important. The author has known cases in which it was impossible to run rather stiff woven belting in this connection,

when a very pliable woven belting or a good leather belt immediately gave every satisfaction.

In setting gallows pulleys for either a ring-frame or fly-frame we may start off with that one of the two pulleys from which the belt leads off the top and is then pulled upon the under side of the line-shaft drum. This pulley must be set parallel to the line-shaft drum and directly opposite thereto. At the same time a plumb dropped from the outside edge of this gallows pulley may touch the top of the frame-end fast pulley about $\frac{1}{2}$ inch or so from the edge next to the loose pulley.

The second gallows pulley receives the belt from the line-shaft drum and need not be directly opposite or parallel to the line-shaft drum, but must be set to the best angle for keeping the belt in position—usually a slight variation from the parallel and with the belt pulling aslant from line shaft to gallows pulley.

In such a case the half cross in the belt may be put in that part of the belt which passes from the first gallows pulley to the under side of line-shaft drum, and a quarter cross may come in each half of belt from gallows pulley to frame-end pulleys.

With gallows pulley driving there is sometimes trouble in getting the gallows pulleys pointing accurately towards both the line shaft and the frame pulleys.

A good flexible belt with a good face on has often been a genuine cure for such a case.

In setting gallows pulleys, a plumb line from the gallows pulleys should point slightly up to the line-shaft pulley, and should also point to the outside diameter of pulleys on frame. This belt on top should come from line-shaft pulley to gallows pulley pointing the slightest bit downwards and the return portion of belt on top will pass down from gallows pulley to line-shaft drum underneath.

The gallows pulley feeding on to the driving drum on line shaft must be directly opposite to the driving drum, and the shaft of this gallows pulley must be parallel with the line shaft.

The other gallows pulley should be set at a suitable angle to carry the strap correctly.

Half-crossed Belt. (Fig. 88.)

In driving by half-crossed belt on combers, ribbon machines, bobbin and fly-frames, ring-spinning or ring-doubling frames, one or two simple setting rules need attention if the belt is to keep easily on either the fast or loose pulley as required.

In the diagram for example we may start from the left and take the belt at 1 and 2 to be passing line-shaft pulley to frame-end pulley, according to the direction required for the tin roller

drive. In either one or two a plumb dropped from the working edge of the driving drum upon the frame pulleys may touch the fast pulley at from $\frac{3}{8}$ to $\frac{5}{8}$ inch from that edge which comes next to the loose pulley.

This represents one essential condition. The second requirement is obtained when facing the length or parallel of the line shaft.

In this second case a plumb line may be dropped from the centre of line-shaft drum and come against the outside edge or diameter of either of the frame pulleys. The belt will lead from this outside surface of frame-end pulleys up to the line-shaft drum. Nos. 3 and 4 are for gallows pulley driving.

Driving of Ring-Frame.

Electric driving has been adopted more rapidly for ring spinning and ring-doubling frames than perhaps for any other machines in

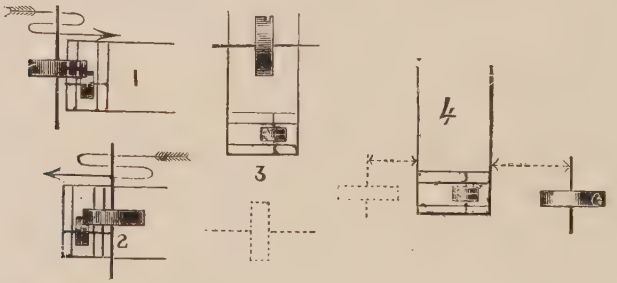


FIG. 88.

a cotton mill. A ring-frame is well adapted for direct individual motor driving by fixing the motor directly upon the extended tin roller shaft by means of any ordinary coupling.

The required revolutions per minute—about 700 to 900—of the tin roller, is a very suitable speed for motor of 4 or 5 horse power, and both motor and starter can be very conveniently arranged for. At the same time the starting load of a ring-frame does not differ very greatly from the running load, and this favours direct motor driving in the manner above described. Cards, mules, and openers, for example, differ greatly in this respect from ring-frames.

Yet again, it does more good than harm to the threads and winding-on for a ring-frame to be suddenly started.

Against these advantages of direct motor driving there is the difficulty in altering revolutions per minute of tin roller if twist, speed, or production considerations so require.

A short counter shaft for two frames may have the motor between the two top pulleys, and both the latter easy to get at.

Ring-Frame Guides for Rovings.

A form of guide is often found on ring-spinning frames, consisting of a vertical aperture for each pair of rovings in the guide tin, but not open either at top or bottom. This guide aperture is twisted so that it keeps the rovings in a very narrow path, and prevents separation of the pair of rovings, while at the same time an aperture is obtained which is sufficiently wide for the operative to readily thread any broken rovings. No middle guide tin is needed to help this kind of back guide, especially as the width of roller boss is sufficient to prevent reasonable chance of rovings running off at the ends of the rollers. Due to the wide spindle gauge used on ring-frames for twist, it is quite common to employ rollers with one boss per thread, and each boss to be about $1\frac{1}{4}$ inch wide, which is very different from the $\frac{5}{8}$ inch or $\frac{3}{4}$ inch often used on the fine-spinning mule. An effort should be made to prevent the rovings from rubbing against the top of the vertical guide used at the ring-frame, as this unnecessarily chafes the roving.

The Guide Rods.

This introduces the subject of the height and forward position of the guide rods used between the creel and the rollers on mules, ring-frames, and fly-frames. We have no hesitation in affirming that these are frequently in wrong positions either vertically or horizontally. Experiments have been made which clearly demonstrate that bobbins can be pulled round much more easily when the rovings are passed round the guide rods at certain angles than is possible at other angles. Also that very often a more favourable passage through the guide apertures can be secured by careful attention to the proper adjustment of the rods. For example, the thickness of those round guides varies all the way from 12's wire used in some cases, to round wood rods of 1 inch thickness used in many other cases, while the Knowles revolving guide is more like 2 inches in diameter. The latter are certainly useful in helping forward rovings which are very weak from deficiency of twist, very fine hank, or cotton too poor for the counts of yarn, but some people object to the trouble of keeping them clean, while others will not pay the first cost. In the opinion of the writer it is very probable that positively revolving rollers, tubular but not perforated, say 1 inch diameter, surface speed three-quarter that of the rovings, would be of considerable advantage in many cases.

The Erection of a Ring-Frame.

Ring-frames may be set out to run parallel with the driving shaft or at right angles thereto, the latter being the most used method, either with half-crossed belt driving, or with gallows pulleys, which give a stronger drive and longer chief belt. Usually the first duty is to draw a chalk line on the floor running lengthwise of the frame. Drop a plumb from line shaft, making two centre dots on the floor a few feet away from each other. Connect these marks by a chalk line, then draw a second chalk line at right angles with the first one.

All the details of mechanism should be well cleaned from grease before erection, and the pieces of beam and girder rails should be laid in consecutive order along the chalk line, every maker putting some consecutive number, letter, or mark on the different pieces, so that a good fit of all parts shall be easily and certainly secured. Naturally the samsons or spring pieces must also be laid alongside the girders, and also in proper order from the gearing end. If more than one frame is being erected each frame will have a distinguishing letter, mark, or numeral to keep one frame clear from another. Starting at the gearing end we may put up the large frame end, and attach the gearing end rails. Fix the end samson to the girder rail, level with a spirit level, raise or lower the end spring piece till the rails are level, keeping the intermediate spring piece off the floor. Take care to have the frame-end pulleys in correct position for driving, this being almost more important for half-crossed belt than any other method, especially with very large diameter of top-driving drums. Now proceed to attach all the other spring pieces and girder rails, and at the finish attach the off-frame end piece. Girders should be levelled both ways. Afterwards stretch a line along the stands, and allow about $\frac{1}{8}$ inch drop in every 12 yards. Properly line up the stands, and also make the frame straight sideways by running a line along the sides of the rails. Everything should be securely fastened and screwed up, and then we may turn our attention to the connections of the ring rails. Begin with the poker tubes, and make these truly vertical, place every poker in position, and take care to have it working quite easily. The traverse rocking rails for moving the pokers may be put into working position, and the adjustable pieces at the bottom of the pokers. We should now be ready for placing the ring rails on the pokers. Afterwards we may proceed to erect the various parts of the building motion, and connect this by chains and rods to the cross shaft of the lifter.

Erection.

The poker tubes may be set vertical by the aid of an erecter's cone and spindle. Every poker should move up and down easily in its tube.

Secure the hangers of the rocking levers on one side of frame and place the rocking levers in position, and then secure the hangers on other side of frame.

Place the poker boots on the pokers and the bowls in the rocking lever arms.

With ring rails in position all ring rail and poker movement should be free.

Fully couple up any parts of builder motion and ring rail connections, chains, copping lever, quadrant, or rocking lever, not hitherto attended to.

With the ordinary cop-shaping builder motion the bowl of the copping lever should be in the hollow of the so-called heart cam, and then the rails set so that the top of each ring is $\frac{1}{8}$ inch above the lowest winding-on point at the bottom of the lift, all chain connections and lifting chains being in position for this.

At this time and setting the snug or coning finger on the chain bowl should be set to its intended maximum chain-shortening effect with ring rails, heart cam, and coning finger in positions indicated. The strong vertical chain of copping motion should be secured to its top and bottom blocks or bowls, a spirit level being sometimes used to help this setting on top of upper block.

Too much use of coning finger will make bottom cones of bobbins too short and thick, but it is always adjustable for amount of use, and there is a set-screw to check the winding back of shaper by handle at doffing times.

Occasionally the straight lift is used on a ring-frame, and the setting should then fix the winding point at both top and bottom of bobbin length. Such straight lift bobbins of roving frame build are good for side unwinding and for keeping bottom layers of yarn very clean.

With ring rails in position, rocking levers coupled up, other levers in position, balance weights may now be applied and adjusted to leave the ring rails somewhat heavier than the weights and levers, so that ring rails will descend by their own weight and with sufficient firmness when the thin part of copping cam comes opposite its bowl. A check should be kept on the highest and lowest winding-on bobbin points on both sides of frame and necessary adjustments made.

Positions for tin roller bearers and pedestals are probably marked on the framing, and these may now receive attention and bearers lined up to end pedestals. Untrue tin rollers will shake

any frame, need much lubrication, and soon wear the bearings. All tin cylinders to be firmly coupled up by means of the usual slotted arbors and set-screws, with screws in slots of arbors and no slack screws left. Be sure different tin roller lengths are in correct order according to whatever numbers, dots, or marks, may have been adopted.

Tin rollers being completed, the thread rails and lappets may be all fitted up, thread rail lifting arrangements adjusted for hand-lifting, noting that the thread rails should sit firmly in position against the roller beam.

Spring-piece stretchers to be replaced, and filling-in boards placed in position between the two roller beams and across the framing.

Roller stands to be re-lined, steel rollers to be coupled up correctly according to letters and numbers.

Each thread board may be set $\frac{1}{8}$ inch to one side to suit the direction of twisting, setting from the centre of the ring.

When the more usual long roller weights are used these may now be hooked upon their respective hooks in position even before the rollers are put in.

Loosen the slides and place all cap bars in position, starting at the gearing end, taking care to work by the distinction numbers, letters, or dots that are adopted, the steel rollers may now be coupled up and placed in position end to end of frame.

The rollers being all coupled you may extend a line along the side of the front rollers and adjust the stands sideways to this line. Be careful to have all steel rollers revolving freely in their bearings and not acting too heavily against some bearings and insufficiently upon others.

All spindles to be now dropped into position and adjusted to centre of ring by means of an ordinary washer gauge—one for each diameter of ring. The cone and block gauge is less used than formerly. Each spindle has a limited amount of adjustment in any direction. Small steel thread clearers, set to just clear the traveller. Thread wires firmly screwed in thread boards, adjusted by plumb-bob to centre of spindle or bobbin and snarl preventers set to clear the path of the yarn.

Starting and Working of a New Ring-Frame.

The starting of a new machine is perhaps the most critical and important part of its career, and affords a fair criterion of the skill and care expended in building the frame, erecting it, and the adjustment of its various parts. One of the essential features in gaiting-up is to see that the bearings are thoroughly cleaned and lubricated. For some time after starting strict attention should be

given to this feature of keeping all bearings efficiently lubricated, as there is often at first a distinct tendency for some bearings to heat, and unless this is checked the bearing may soon be ruined. Care will doubtless have been taken to have all the bolts well screwed up, but after starting and working a short time some of these may be tested again with the screw key. The spindles should be banded, and allowed to run a few hours before piecing up, and after running it is advisable to have them readjusted each to the centre of its ring, this being often done whilst running. It is possible also that some of the thread wires might need re-setting, and this should receive attention. The roller traverse motion should be set to give the maximum amount of traverse consistent with absolute freedom from running off at the ends and taking care to have the traverse moving to within equal distances from each end. The utmost care is needed in applying the correct size of twist wheel, builder wheel, and change pinion for counts. After a new frame has worked for about two days the dirty oil may be pumped out and the spindles re-oiled, then a week or so may be allowed to elapse before repeating this operation, after which it may be sufficient to add a little fresh oil every month or so, and to pump the oil out about three or four times annually. Attention to such points as enumerated will undoubtedly tend to prolong the life of a frame and give easy working of same.

During working the bearings of front rollers may be oiled two or three times per week, and other rollers once per week. All tin roller bearings should be kept greased, and then oiling may suffice once per week. Full scouring twice or thrice per annum, under-clearers picked every two hours, thread boards, ring rails, etc., wiped about every two and half hours.

After working a few months a number of bearings and fixings may be tested.

If a ring-frame is skilfully and carefully erected, there should be little trouble in gaiting it up. Adjustment of rollers to correct distances apart to suit the cotton and counts, correct twist, correct weights of traveller, correct change wheels, correct adjustments of spindles, thread wires, traverse motions, copping motions, all parts well cleaned and oiled, correct rovings in the creel, correct inclination of roller stands, anti-ballooning appliances—are of vital importance.

Ring-Frames. To Spin 16*'s to* 20*'s Twist from Short Staple Cotton.*

In specifying for any new ring-frames for any counts it would be necessary to give such details as the following: Number of spindles in each frame, spindle gauge, kind of spindle, speed of

spindle, direction in which spindles are expected to revolve, diameters of rings, diameters of spindle wharves, and of tin roller, diameters of each line of rollers, whether steel rollers shall be case-hardened all over, or in the necks only, roller drafts, average roller centres or settings, method of weighting and of clearing the top rollers, counts of yarn expected to spin, and from what hank rovings, single or double roving, character of bottom creel, single or double tin rollers, tin roller guards, diameter and speed of line shaft drum, nature of main drive, amount of twist, kind of separator, whether hank indicators and rope driving for tin rollers will be used.

The number of spindles varies in ring-frames as with other machines, but might reach about 500 or so in this case. The rather low twist per inch required may limit the spindle speed to possibly 7,500 r.p.m., but this is affected by the twist constant, the kind of cotton, and ability of operatives. The gauge of spindle might be for conditions stated $2\frac{5}{8}$ inches, the inside diameter of ring $1\frac{5}{8}$ inch, the lift 5 inches. Double tin rollers are mostly preferred, with a diameter of about 10 inches. For Indian cotton twist yarns the twist constant may be 4 to $4\frac{1}{4}$, and the spindles will usually revolve twist way. The total roller draft may be about 6, and for 24's yarn from single roving this would require a roving of about 4-hank. Bottom steel draft rollers front and back $\frac{7}{8}$-inch diameter, and middle roller $\frac{3}{4}$-inch. Top rollers $1\frac{1}{16}$-inch, $\frac{7}{8}$-inch, and $1\frac{3}{4}$-inch, reading from front to back, before being clothed. A two-height creel will be suitable, and creels of the Birkenhead type are best. Inclination of roller stands about 26 to 28°.

Tin roller guards for ring-frames are becoming more and more adopted, but some spinners are preferring to revolve their tin rollers to strike outwards from the bottom in place of using guards. Metal thread boards of a good type are the best, although of greater first cost. A good line shaft speed for these counts is about 300 r.p.m., spindle wharve $\frac{7}{8}$-inch diameter, spindle speed 7,500, frame-end pulleys 12-inch diameter, from which the diameter of line shaft drum may be calculated. Separators are much used for such counts, and the thin plain polished plate gives good results, but many prefer deep separators such as the blinker.

Working of Ring-Frames.

After a new ring-frame has worked for two or three days it is a good plan to pump the dirty oil out of the spindle bearings, and a fresh supply of good thin oil put in. After working a week or ten days, pumping and re-oiling may again take place, but afterwards re-oiling may be done every month, and pumping three or four times a year. A good deal of fluff and fibre accumulates on

the rollers for these numbers and for Indian cotton, so that bottom front rollers may need oiling two or three times per week, and the other lines possibly once per week. Under clearers picked four or five times daily, thread boards and ring rails wiped about four times per day.

Fluted rollers are not taken out so frequently as formerly, but scouring may be done about every three months or so. In all such practical details as foregoing opinions and actual customs vary with different firms. Care should be taken that bobbins fit the spindle very well, and a spindle-top tight fit is often required. Unfortunately bad spinning occurs on ring-frames as well as on mules, and possible causes may be specified as below. Worn travellers and worn rings, thread board wires worn or out of centre, draft rollers set too closely together or too widely apart for the length of cotton fibre ; rollers dirty, needing oiling, or leather rollers needing re-covering. Spindle vibration should be remedied as soon as possible, and may be due to straining of spindle, defective bobbins, or binding of inner tube of spindle. Badly drafted rollers, poor cotton, cold rooms, incompetent operatives may also be contributory causes of bad spinning.

New Bobbins.

All new bobbins are carefully tested in dimension and fit before leaving the works, but it is advisable to test every bobbin in the place once in every twelve months. For some makes of spindle the bobbins are made a good fit or grip only for the top of the bobbin, while the base of the bobbin is made an easy fit on the sleeve of the spindle. This is considered advisable to prevent the bobbin from automatically working up the spindle and causing the latter to vibrate excessively. In cases of using a small cup on the spindle for the reception of the base of the bobbin care is necessary to have the exact kind of fit which is found to give the best results. It is necessary for the enamelling to be done well in order to stand the treatment due to conditioning the yarn on the bobbin by placing the latter in a water tank of some kind.

A good deal of damage has been caused to bobbins by cutting wasted portions of yarn from them, and only careful operatives or experts should do this. Machines are now at the disposal of those who require them for quickly and easily stripping the waste yarn from any ring bobbin without the use of a knife. The bobbin is placed on a suitable bracket, a handle is smartly turned, and a circular stripping bracket is drawn over the length of the bobbin and set to strip off the surplus yarn. It remains to be seen whether such appliances will receive anything like general adoption.

The Spindle and Spindle Bands.

Three examples of ring-frame spindles by Messrs. Hetherington are shown in the figure.

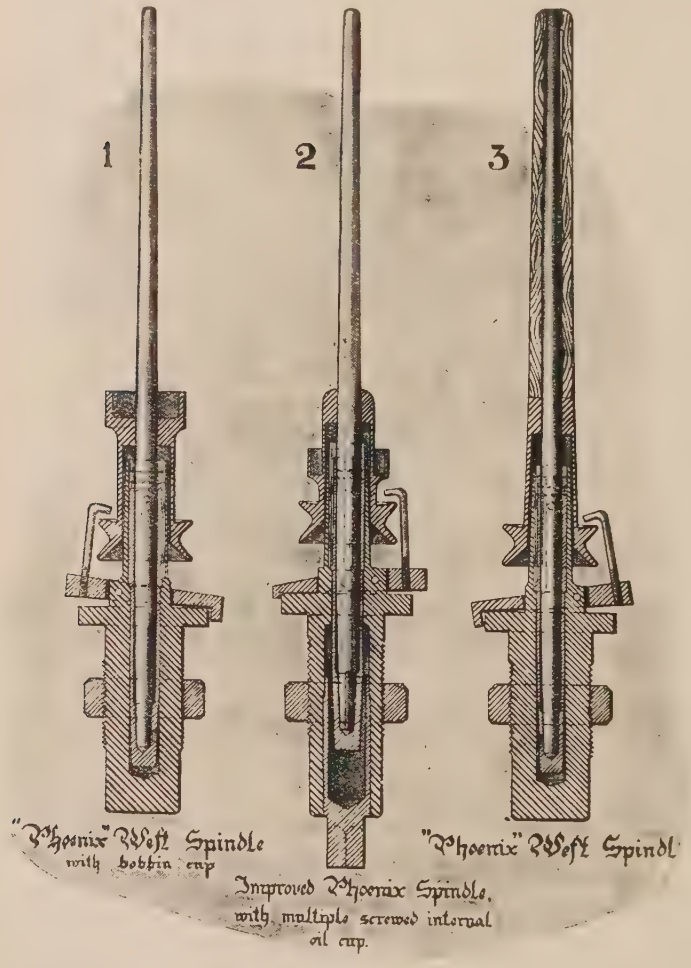


FIG. 89.

The spindle of a ring-frame is a wonderful piece of mechanism, the result of about sixty years of special experiment and development. The spindles of a mule or ring-frame are made in larger number and are actually revolved at higher speeds than almost anything else in the way of rotary mechanism. The spindle of a mule is very simple, but that of a ring-frame is quite complex, and it is wonderful how it will continuously work at very high speeds and often with more or less unbalanced bobbins. It is now invariably self-contained or, in other words, the bolster and footstep constitute practically one long bearing complete with the spindle, so that all the parts are adjusted at one operation. A complete ring-frame spindle may be said to contain the following parts: The spindle itself with its wharve and sleeve, the spindle holder to prevent the spindle from lifting away when a bobbin is plucked off the spindle, the inner tube in which the spindle is accurately fitted, and the combined bolster and footstep which is screwed fast to the spindle rail. The separate footstep and bolster of the mule spindle are utterly unable to meet the conditions imposed on a ring spindle by the carrying of the comparatively heavy bobbin. Well-made spindles will now revolve steadily at any speed desired in the mill so long as there is not excessive breakage of the threads. This is in spite of the unsatisfactory nature of the load imposed on the spindle by the yarn and the bobbin by pulling the traveller round the ring by the resistance of the air to the yarn and traveller by uneven distribution of load, by variation in the centre of gravity, and by the pull of the spindle band, especially if the latter is very tight. The pull of spindle bands varies a very great deal in extent, going from possibly less than half a pound in the case of a very slack band up to 7 or 8 lb. in a very tight band. Something like $2\frac{1}{2}$ to $3\frac{1}{2}$ lb. is perhaps a fair average-working pull in a modern spindle. Variable pull of spindle bands is often a source of much trouble in ring-frames, and especially if there are great atmospherical changes or they happen to become saturated with oil thrown off the spindle bearings or the tin roller bearings. Changing from dry to wet weather will tend to contract the bands unless a room is evenly humidified, and tend to increase the power required to drive the spindles very considerably. The same effect may be produced first thing in the morning, especially if the rooms have not been well steamed during the night-time.

Slack bands cause variation and loss in twist, while excessively tight spindle bands add to cost in driving and in renewal of bands.

Ring-Frames: Calculated Production for Ten Actual Working Hours of Frame.

Twist (*Turns* = $\sqrt{Counts} \times 4$).

Nos.	Diam. of Ring.	Gauge.	Turns Per Inch.	Diam. of F.R.	Revs. of F.R.	Inches Delivered Per Min.	Revs. of Spindles Per Min.	Hanks Per Spl. Per 10 Hours.	Lb. Per Spl. Per 10 Hours.	French Nos.
	In.			In.						
5	2	3	8·94	$\frac{7}{8}$	203·5	559·29	5000	11·09	2·21	4·23
	2	3		$\frac{7}{8}$	244·2	671·14	6000	13·31	2·66	
7	2	3	10·58	$\frac{7}{8}$	189·16	519·83	5500	10·31	1·472	5·92
	2	3		$\frac{7}{8}$	206·37	567·107	6000	11·252	1·607	
	2	3		$\frac{7}{8}$	223·5	614·36	6500	12·18	1·74	
10	$1\frac{3}{4}$	$2\frac{3}{4}$	12·64	$\frac{7}{8}$	172·74	474·7	6000	9·418	·9418	8·47
	$1\frac{3}{4}$	$2\frac{3}{4}$		$\frac{7}{8}$	194·32	534·01	6750	10·59	1·059	
	$1\frac{3}{4}$	$2\frac{3}{4}$		$\frac{7}{8}$	215·92	593·35	7500	11·77	1·177	
12	$1\frac{3}{4}$	$2\frac{3}{4}$	13·85	$\frac{7}{8}$	157·64	433·21	6000	8·595	·716	10·16
	$1\frac{3}{4}$	$2\frac{3}{4}$		$\frac{7}{8}$	183·9	505·41	7000	10·02	·835	
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	183·7	577·61	8000	11·46	·955	
14	$1\frac{3}{4}$	$2\frac{3}{4}$	14·96	$\frac{7}{8}$	145·95	401·07	6000	7·957	·568	11·86
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	148·8	467·91	7000	9·283	·663	
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	170·1	534·75	8000	10·61	·758	
16	$1\frac{3}{4}$	$2\frac{3}{4}$	16	1	129·26	406·25	6500	8·06	·503	13·55
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	149·1	468·75	7500	9·3	·581	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	169	531·25	8500	10·54	·658	
18	$1\frac{3}{4}$	$2\frac{3}{4}$	16·96	1	121·8	383·25	6500	7·604	·422	15·25
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	140·7	442·21	7500	8·77	·487	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	159·4	501·18	8500	9·944	·552	
20	$1\frac{5}{8}$	$2\frac{5}{8}$	17·88	1	124·5	391·49	7000	7·765	·388	16·94
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	142·35	447·42	8000	8·877	·443	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	160·15	503·35	9000	9·985	·499	
22	$1\frac{5}{8}$	$2\frac{5}{8}$	18·76	1	118·72	373·13	7000	7·403	·336	18·63
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	135·6	426·43	8000	8·46	·384	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	152·64	479·74	9000	9·518	·432	
24	$1\frac{5}{8}$	$2\frac{5}{8}$	19·59	1	113·69	357·32	7000	7·09	·295	20·33
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	129·92	408·37	8000	8·102	·337	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	146·16	459·41	9000	9·115	·379	
26	$1\frac{5}{8}$	$2\frac{5}{8}$	20·39	1	117	367·82	7500	7·289	·28	22·02
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	132·7	416·87	8500	8·271	·318	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	148·3	465·91	9500	9·244	·3554	
28	$1\frac{5}{8}$	$2\frac{5}{8}$	21·16	1	112·7	354·44	7500	7·032	·251	23·72
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	127·6	401·7	8500	7·97	·284	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	142·9	448·96	9500	8·9	·317	
30	$1\frac{5}{8}$	$2\frac{5}{8}$	21·9	1	116·2	365·3	8000	7·248	·2416	25·41
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	130·8	410·9	9000	8·15	·271	
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	145·2	456·62	10,000	9·06	·302	
32	$1\frac{5}{8}$	$2\frac{5}{8}$	22·62	1	112·5	353·67	8000	7·017	·219	27·10
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	126·6	397·87	9000	7·894	·246	
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	140·6	442·08	10,000	8·771	·274	
36	$1\frac{5}{8}$	$2\frac{5}{8}$	24	1	106·1	333·33	8000	6·61	·183	30·49
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	119·3	375	9000	7·44	·206	
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	132·5	416·66	10,000	8·26	·229	
40	$1\frac{1}{2}$	$2\frac{1}{2}$	25·29	1	100·6	316·33	8000	6·276	·1569	33·88
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	113·2	355·87	9000	7·06	·1764	
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	125·9	395·4	10,000	7·845	·1961	
44	$1\frac{1}{2}$	$2\frac{1}{2}$	26·53	1	89·98	282·7	7500	5·609	·127	37·27
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	102	320·39	8500	6·359	·144	
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	107·31	358·08	9500	7·104	·1615	
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	112·9	377	10,000	7·48	·17	
48	$1\frac{1}{2}$	$2\frac{1}{2}$	27·71	1	86·1	270·66	7500	5·37	·1118	40·66
	$1\frac{1}{2}$	$2\frac{1}{2}$		1	97·59	396·74	8500	6·086	·1268	
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	102·7	342·83	9500	6·802	·1416	
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	108·1	360·89	10,000	7·16	·1491	
50	$1\frac{1}{2}$	$2\frac{1}{2}$	28·28	1	78·7	247·52	7000	4·911	·098	42·35
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	84·7	282·88	8000	5·612	·1122	
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	95·3	318·24	9000	6·314	·1262	
	$1\frac{1}{2}$	$2\frac{1}{2}$		$1\frac{1}{16}$	105·9	353·6	10,000	7·016	·1403	

Ring Weft Twist Per Inch = $\sqrt{Counts} \times 3{\cdot}5$.

Nos.	Ring.	Gauge.	Turns Per Inch.	Diam. of F. R.	Revs. of F. R.	Inches Per Min.	Revs. of Spindle.	Hanks Per 10 Hours.	Lb. in 10 Hours.	French Nos.
				In.						
5	1⅛ or 1¼ inch ring when using wood bobbins = 2¼ inch-gauge.	1 inch ring when using paper tubes = 2 inch-gauge.	7·826	⅞	232·49	638·89	5000	12·67	2·53	4·23
				1	278·9	766·67	6000	15·2	3·04	
7			9·257	⅞	216·2	594·14	5500	11·788	1·68	5·92
				1	235·86	648·15	6000	12·86	1·837	
				1	255·5	702·17	6500	13·931	1·99	
10			11·06	⅞	189·18	519·89	5750	10·31	1·03	8·47
				1	213·86	587·7	6500	11·66	1·16	
				1	238·52	655·5	7250	13·0	1·3	
12			12·12	⅞	173	474·42	5750	9·41	·78	10·16
				1	202·6	556·93	6750	11·05	·92	
				1	203·52	639·43	7750	12·68	1·05	
14			13·09	⅞	159·84	439·26	5750	8·715	·622	11·86
				1	164·13	515·66	6750	10·13	·73	
				1	188·45	592·05	7750	11·74	·838	
16			14	1	136·36	428·57	6000	8·503	·53	13·55
				1	159·15	500	7000	9·92	·62	
				1	181·88	571·42	8000	11·337	·708	
18			14·84	1	128·69	404·31	6000	8·022	·445	15·25
				1	150·14	471·7	7000	9·359	·519	
				1	171·59	539·08	8000	10·69	·593	
20			15·65	1	132·25	415·33	6500	8·24	·412	16·94
				1	152·54	479·23	7500	9·508	·475	
				1	172·88	543·13	8500	10·776	·538	
22			16·41	1	126·08	396·1	6500	7·859	·357	18·63
				1	145·46	457	7500	9·067	·412	
				1	164·87	517·97	8500	10·27	·466	
24			17·14	1	120·7	379·22	6500	7·524	·313	20·33
				1	139·28	437·57	7500	8·681	·361	
				1	157·84	495·9	8500	9·839	·409	
26			17·84	1	120·4	378·36	6750	7·507	·288	22·02
				1	138·2	434·41	7750	8·619	·331	
				1	156·1	490·47	8750	9·731	·374	
28			18·51	1	116	364·66	6750	7·235	·258	23·72
				1	133·2	418·69	7750	8·307	·296	
				1	150·4	472·71	8750	9·379	·334	
30			19·15	1	120·4	378·59	7250	7·511	·25	25·41
				1	137	430·8	8250	8·547	·285	
				1	153·7	483·02	9250	9·583	·317	
32			19·79	1	116·5	366·34	7250	7·268	·227	27·10
				1	132·6	416·87	8250	8·271	·258	
				1	148·7	467·4	9250	9·273	·289	
36			21	1	109·8	345·23	7250	6·85	·19	30·49
				1	125	392·85	8250	7·794	·216	
				1	140·2	440·47	9250	8·739	·242	
40			22·13	1	104·2	327·6	7250	6·5	·162	33·88
				1	118·6	372·79	8250	7·396	·1849	
				1	133	417·98	9250	8·293	·2073	
44			23·21	1	92·57	290·82	6750	5·77	·131	37·27
				1	106	333·9	7750	6·624	·15	
				1 1/16	112·9	377	8750	7·48	·17	
				1 1/16	118·7	396·38	9200	7·864	·178	
48			24·24	1	88·6	278·46	6750	5·525	·115	40·66
				1	101·7	319·72	7750	6·343	·132	
				1 1/16	108·1	360·97	8750	7·162	·149	
				1 1/16	113·5	379·53	9200	7·538	·157	
50			24·74	1	83·6	262·73	6500	5·212	·104	42·35
				1 1/16	90·8	303·15	7500	6·014	·120	
				1 1/16	102·9	343·57	8500	6·817	·136	
				1 1/16	111·4	371·86	9200	7·378	·1475	

Spindle Holder.

One of the attachments to the complete ring-frame spindle consists of the spindle holder. This must not be confused with the bolster or footstep bearing, but is a small device for preventing a spindle from being pulled out of its bearings every time a bobbin is plucked off the spindle. It is well known that a ring-frame tube or bobbin must bite or grip the spindle firmly at least at one point to prevent the bobbin from vibrating upwards during working. It follows that a certain degree of force is necessary for pulling a bobbin off, and hence the need for the spindle holder. Various devices have been, or are at use more or less for this purpose, but in every case it is requisite for the holder to permit the spindle to drop by its own weight back into position. In some cases the holder is compounded with the lid of a special oil tube cast on the long spindle bearing. In very many cases a spring clip has been employed behind the spindle, making it necessary for the operative to feel round the spindle to the spring clip before the spindle could be lifted out. The small lever holder has, however, now become far and away the most adopted type of spindle holder, being made by practically every ring-frame maker in existence, now that all patent rights have expired. It is comparatively cheap and easy to apply, very seldom goes wrong, gives a really satisfactory action, and is lifted up from the front for removing a spindle with practically no trouble or delay.

The Ring.

The ring is made from bar steel drop forged into shape for turning. These forgings, after being properly treated to destroy the scale, are turned. After being turned they are inspected, all substantially perfect rings going to the polishers, from them to the hardening furnace, again to the polishers, and finally to the inspectors. Rough turned rings, that is to say rings with improper surface, but within standard gauges of size, are ground, hardened, and polished. . . . Great care must be used in forging the blanks from which the rings are turned to know that the metal is not overheated, and yet shall fill the dies. Any large excess of heat, or not enough heat, means a spoiled forging. The hardening of rings is also of the utmost importance. Rings not hard enough, or unevenly hardened, will wear out rapidly. Rings hardened too much, that is, rings hardened at too high a degree of temperature, or exposed to heat for too long a time, become changed in character, the metal becomes granulous and rotten, and the surface becoming glassy. The inspection of rings is in itself an art. Rings are gauged with snap gauges of slight variation, not in excess of

$2\frac{1}{2}$ thousandths of an inch, for concentricity of flange, are tested for hardness, for roughness, for smoothness of finish, and for general appearance.

Single rings have always received much favour in England, but it is stated that double or reversible rings are popular in America.

20 to 25° angle of rollers is a much used range, but as low as 15°, and as high as 35° have been used.

Single v. *Double Rings.*

The question often arises as to whether the single or the double ring is to be preferred in our ring-spinning mills. The double ring has apparently been the favourite in the U.S.A. for many years past, and a consideration of the subject would lead almost anyone to conclude the double ring would also be the favourite in England. Such, however, is not the case, and our English makers apparently do a much larger business with the single than with the double ring. The single ring only possesses one working flange or rim for the traveller to revolve upon, whereas the double ring has two working flanges, and is reversible, so that when one edge is worn the ring may be turned upside down, and the other flange be used. The single ring is complete in one piece, but the double ring is made in two pieces for the purposes of reversing, the lower portion of each ring being held in position by a set-screw passing through the ring rail. With the cast-iron split holder the double ring is simply sprung into a fit with its holder, and the arrangement is exceedingly simple. Plate holders have been extensively adopted in America for the double rings. Any kind of double ring must necessarily be dearer than the single ring, and this may influence the question of which shall be most used, but also there are some other objections to the reversible ring, such as rings getting inadvertently turned upside down, so that the manager or overlooker does not know whether the best or worst flanges are in actual working.

One English firm of ring-frame makers gives the following note with regard to their rings:—

"These are stamped from the solid steel bar, preventing any irregularity of structure which is often the case when the rings are welded. After being turned and polished by automatic machines, they are thoroughly case hardened, and afterwards highly polished, and each ring is carefully tested before leaving the works."

Weighting of Ring-Frame Top Rollers.

There are at least three methods of weighting the top rollers of a ring-frame. One method resembles that adopted on a mule

for spinning coarse or medium numbers, and has all three lines of rollers saddled and bridled together and weighted with one weight and one lever. All three lines of top rollers in this case are leather covered, and of equal diameter. In a second method the front line is dead weighted, and the back and middle rollers lever weighted. The third method appears to be far and away the most adopted of the lot, and somewhat resembles the method adopted for fine-spinning mules, producing fine counts of yarn. With this third method on the ring-frame the back and middle top rollers are self weighted, the back one increased in diameter, so as to be of sufficient weight to draw the cotton firmly from the creel bobbins. The front line is dead weighted from one end of a long round weight which has its other end suspended from a front roller upon the other side of the frame. Owing to the inclination of the rollers and of the weight wires there is slightly less weight on the rollers than as represented by a plain lever calculation, but this does not make much working difference. Loose boss top rollers are extensively adopted for the front lines of a ring-frame and probably give better results than any other method.

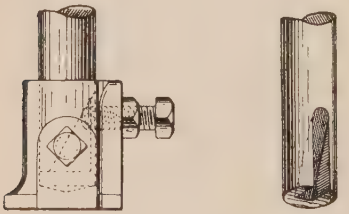


Fig. 90.

Possibly a loss of 10 per cent. represents what is due to inclination.

Gearing Wheels.—These may be machine moulded or cut. There has been a strong tendency in recent years towards the use of cut gearing wheels for the various machines. Taking the case of the change pinions for counts, the author has had a great deal of trouble with cast wheels, and has found cut pinions to run more smoothly. On the other hand, the increasing perfection with which gearing wheels can be moulded appears to point towards the retention of cast wheels in some cases.

It is contended by some that cut wheels run better, but that moulded wheels are more durable. Machine moulded wheels can be made perfectly cylindrical, and also parallel throughout the full width of the teeth. To prevent possible irregularities, they are in many cases afterwards finished with special grinding machinery.

Referring to Fig. 90 (*a*) this improvement allows of the pokers being readily removed for cleaning purposes; when replaced, owing to the special construction, no setting whatever is required, the poker foot immediately fitting to its place, thus saving time when the frames are being cleaned.

Fine Counts on the Ring-Frame.

There is a tendency towards the employment of the ring-frame for the spinning of the finer counts, and a few cases exist where even Sea Islands yarns are spun on the ring-frame. Very many cases exist in Lancashire of the spinning of medium fine yarns from Egyptian cotton. It is no very difficult matter to spin, say, a good 60's, 70's, or 80's, if sufficiently good cotton is given, and especially if combed, double roving. Indeed, 120's are occasionally spun commercially in this country and this is regularly done in America.

The building of spinning mules fluctuates.

In 1901 for example, mule makers were unable to keep orders fulfilled.

In 1921-2 mules were hardly built at all while ring-frames could scarcely be built fast enough.

Many people find considerable benefit from the application of humidifiers in their ring spinning rooms for the spinning of fine counts. One of the reasons for this is that improved atmosphere has sensibly diminished the number of fainting cases amongst the women tenters.

In the spinning of fine counts it is also found advantageous to have the difference of diameter between bobbins and rings as little as convenient, assistance being rendered in this direction by the small diameter of the fine yarn enabling a good length of yarn to be wound into a limited space.

It is well known that the inclination of the roller stands on a ring-frame greatly improves the spinning by enabling the twist to run right up to the nip of the rollers.

This inclination is very usually about 25°, but may be anything from about 15° to 35°, while cases exist where even these limits are exceeded.

It will be understood that the spinning of fine counts is generally considered to require a good deal of inclination.

Bobbins.—Wilson Bros. make a serrated shield, which they claim will make it practically impossible for the shields to come loose. These shields are made with spikes, *i.e.* they are serrated on the inner edge, and these serrations or spikes are pressed into the wood of the bobbins, rendering them secure under almost all circumstances.

Many of our practical readers are well aware that often there is much trouble and loss owing to the frequent breakages of the flanges of the flanged bobbins often used in connection with winding, warping, gassing, and other frames. The above firm made a patent flange binder. This is a narrow fluted steel ring, which necessarily strengthens the flanges to an enormous extent, and

although these steel rings necessarily add to the first cost, it is a great question whether the extra cost is not fully met by the longer life and greater usefulness of the bobbins. The writer has handled and used such bobbins, and can testify to their great strength. Another speciality in this connection is the patent endless steel tyre, which has the additional recommendations that it renders the periphery of the flange perfectly smooth. It is made with a double edge of metal on the inner edge of the flange.

Bobbins for Ring-Frames.—For a good number of years now ring spinning has been receiving a good deal of attention and adoption in this country. The tendency towards increased speeds and the desire for increased quality has rendered the production of perfectly accurate bobbins an absolute necessity. Wilson Bros. make the Cornholme shield. This shield is made with a double or folded over edge, which is pressed into the wood, thus giving a smooth point and great strength to resist crushing strain.

In consequence of the introduction of conditioning yarn on the bobbin, the difficulties of maintaining the bobbins perfectly true have been vastly enhanced, and to the author's positive knowledge this has been a great source of trouble and anxiety to many overlookers of ring-frames.

These difficulties have rendered it necessary to introduce bobbins more able to resist the effects of moisture than those formerly in use.

About 1889 Wilson's put down a special plant for the enamelling of wood bobbins, and this new departure proved so successful that the enamelling department has had to be increased, and the enamelled bobbins are in very extensive use in all parts of the world.

Bobbins for Cotton Spinning.

Birch is used for all card-room bobbins and a few ring-doubler bobbins, whilst ash, beech and birch are used for skewers. Ring twist or rabbeth, and ring-weft pirns are made chiefly from birch, whilst birch, limetree, and beech go for barrels of warping bobbins, and sycamore, limetree and chestnut form the flanges. For ring-doubler bobbins large quantities of rock maple and some sycamore, two similar timbers.

Ninety-five per cent. of the bobbins used in this and other countries are now fitted with sheet-metal protectors.

The tendency has been to make longer lifts and smaller diameters of bobbins to get more length on, but of course on fly-frames the long collar takes a larger diameter than the short collar, but long collars are very much more used.

Above firm use Whitworth parallel gauges for the bobbins to $\frac{1}{64}$, $\frac{1}{80}$ inch and even $\frac{1}{100}$ inch.

As regards skewers of good hardwood, the bottom point tipped with boxwood is most used. Brass, iron, porcelain, and other substances have been tried with little success.

Finland birch is almost always used for some makes of ring bobbins. It is generally conceded that a ring bobbin should grip the spindle at the top, and this point shall be the only one at which the bobbin grips the spindle, and there should be just a very slight play at the sleeve, and the sleeve shall support the bobbin while the bearing drives it. Opinions differ somewhat on this point, also as to shape of ring bobbin, and rings are often used to prevent slipping off. Conditioning necessitates the use of enamelled bobbins. In ring-doubler bobbins the holes at bottom are often protected to prevent wear.

Full Cop Stop-Motion (*Fig.* 91).

A good many mules and ring-frames work without any automatic full cop stop-motion, the doffing time being more usually left to the judgment of the spinners. A full cop stop-motion may be applied to either machine, and is more usually required when shuttle cops are being spun as it makes considerable difference at the loom if the cops are of wrong size.

As applied to a ring-frame an arrangement is illustrated in Fig. 91.

Length of cop or time for automatic stopping is determined by the adjusting screw in bracket A, fixed on the poker.

When frame is almost ready for doffing, bracket A lifts lever B with each traverse of the ring rail until it releases long lever C and permits it to assume a vertical position. At this moment it is opposite to the finger D fixed on the copping lever, and at the next lift is raised by this lever, and lifts the knocking-off lever E, which releases the catch-lever F, and allows the strap to be moved from fast to loose pulley by spring H, operating through the lever G, and the chain J, which is connected to the setting-on handle.

A compound draft wheel arrangement is obtainable for ring-frames, in which seven draft wheels are used instead of four. In this way two driving change wheels are provided. In some cases the broad carrier for connecting the back roller to the middle roller is placed beneath the rollers.

The Traveller.—The traveller is one of the most useful articles in a cotton-spinning mill, and since its average life may be only about six weeks or so, the quantity of travellers used is very great.

Travellers differ somewhat in shape, but the differences are

very minute, and can only be judged for value by actual experience. Indeed, experience, judgment, and observation are very essential in deciding the best weight or number of traveller for any frame, yarn, or cotton. Harder twist, better cotton, stronger yarn, coarser counts of yarn, smaller ring for other equal circumstances, narrow gauge of frame, absence of anti-ballooning motion, are factors which usually require the use of heavier travellers.

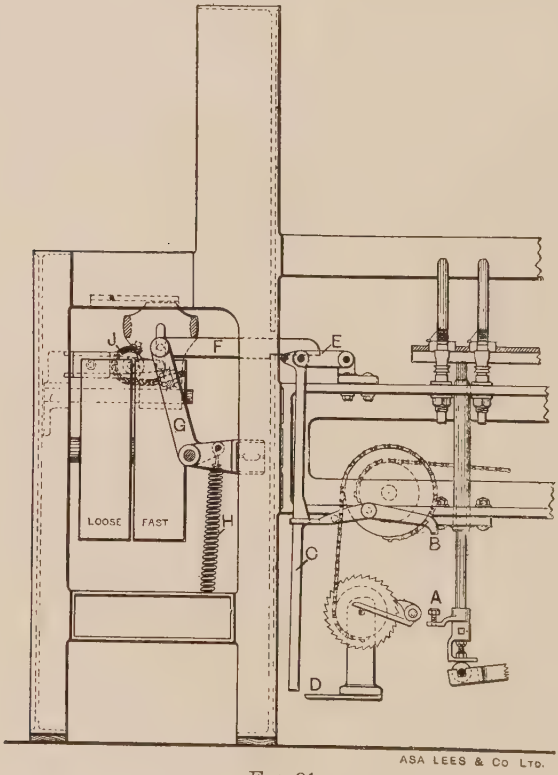


FIG. 91.

Travellers are denoted by numbers, the finest being indicated by a cypher after the number.

Example 20/0 is an extremely light traveller, and the weight increases all the way 19/0, 18/0, 17/0 down to 1/0 which is the heaviest in the cypher series. Then 1 is taken as the next basis, and 1, 2, 3, 4 up to 20 or so, indicates still heavier travellers. The

counts of traveller means that it takes a certain number of them to give a certain weight so that for 15/0's traveller it may take 10 travellers to weigh 3 grains, and for 15's traveller 10 travellers may weigh 42 grains. This may represent the relation of one make of traveller, but there is not the same universally accepted standard in counts of traveller as in counts of yarn, and another make of traveller might give slightly different weights per 10 travellers. This should be remembered when changing the make of traveller. As a rough guide some spinners for average counts assume that 2 counts coarser yarn requires 1 count heavier traveller.

Scouring of Ring-Frame.—Draw-frames, fly-frames, mules, and ring-frames are subject to periodical scouring times in which a chief item is to take the rollers to pieces, thoroughly clean and lubricate them, make any repairs that have been waiting, and finally piece up again and restart, and sometimes occasion is taken to reset the steel rollers. On the ring-frame the threads are first broken in the quickest manner, which will enable the threads to be re-pieced afterwards, a good method being to disconnect the draft wheels. All clearers and top leather rollers are removed, the roller weights being unhooked and saddles removed. Rovings are drawn back from rollers. Formerly it was customary to take all steel rollers thoroughly to pieces at each spigot coupling, both on mules and ring-frames, but experience has shown that there is more to be lost than gained this way, and it is only done occasionally as against ordinary scouring every three, four, or six months each frame.

On a mule the steel rollers are coupled into very long lengths, and at scouring they are simply lifted up from the stands or bearings to permit cleaning of same. The shorter total lengths of ring-frame rollers permit them to be carefully lifted out by several persons and placed upon special bearings for cleaning purposes, and so that the bearings can be freely got at. A convenient method consists of special iron brackets clamped to the roller beam and filled with wood stands or bearings for the rollers.

Cop waste, cleaning cloths, card clothing, and pumice stone are the usual cleaning materials for fluted rollers. The weekly cleaning of the gearing or other parts may be now supplemented by a more complete cleaning through, especially making all oil-holes and bearings clean, and tallow placed in some of these or in steel-roller bearings. In re-assembling, the steel rollers will be re-placed, the rovings drawn through, top rollers replaced, draft wheels re-geared. For quickness in re-piecing on mules and ring-frames, the drawn through rovings are broken off short at the front roller.

Twist Per Inch on Ring-Frame.—The number of twists approximately equal the number of traveller revolutions, and not the spindle revolutions, and it is therefore sometimes argued that the

traveller puts in the twist. If a traveller were taken off, the rollers stopped and frame worked for a short time twist would all the time be put in. If the spindles were stopped there would be no twist.

Delivery of yarn from rollers, r.p.m. of spindles, diameter of bobbins, r.p.m. of traveller all help to regulate the twist.

The traveller does not put in the twist of itself, but its revolutions help to regulate the twist and represent the amount of twist.

To obtain the twist the method is to find inches of yarn delivered per minute, revolutions per minute of spindle, circumference of bobbin, revolutions of bobbin needed to be lost to wind-on the yarn delivered. Subtract revolutions lost by traveller from spindle revolutions and we obtain the revolutions of traveller, which represent the twist. Shrinkage of yarn due to twist will upset absolute accuracy of this calculation but the result is near enough. Length of yarn wound-on is less than length delivered from rollers in spite of traveller drag. Plus one diameter of spindle band to tin roller and spindle warve to help exactness of result in getting spindle speed. There is less twist in the yarn and more strain on it when winding small diameters. For this reason it is often argued that ring twist is more variable than mule twist The writer has often noticed the exact opposite under a good twist tester with magnifying glass, especially when the mule yarn has not had any ratch or gain during spinning. Winding-on twist lost in ring spinning is regained when the yarn is afterwards unwound over the bobbin nose. Unwinding twist at winding frame and from shuttle may somewhat affect a woven cloth.

Revolving Top Clearers on a ring-frame are best kept in position by adjustable fixings which keep the clearers in one position and prevent them falling forward due to use of inclined stands; also these thin holders for clearers enable the clearers to be set to the best working positions.

Waste Ring-Frame.—Ordinary ring-frames are sometimes made for waste spinning, containing much the same mechanical arrangements in regard to building motion, gearing, and spindles, but differing in the creel. The creel may be arranged with surface drums to take condenser bobbins, or to take cheeses of yarn direct from the finisher card. It is quite possible to arrange the front of a condenser carding engine on the winding-frame principle to build each condenser end into a cheese or a bobbin carried on a small tin tube with a large head.

Metal Lappets gain in adoption and there are various makes. Especially useful for hot climates such as India, or Brazil, where wood has a greater tendency to warp or shrink, or when there is likely to be rough usage by workpeople. Almost any make of metal lappet offers ready means for accurate adjustment of the curl or guide eye for the thread, which cannot truly be said

of ordinary wire curl screwed into the wood lappet. Metal lappets are more costly than wood ones.

Anti-ballooning Motions may be had in many varieties from the single wire to the most elaborate blinker separator or the finger-space separator.

They are of most use in high-speed frames, narrow-gauge frames, long-lift frames, and when the yarn demands light travellers.

Tin Roller Speeds under average conditions vary from 700 to 900 r.p.m. and spindle speeds from 8,000 to 10,000 r.p.m.

For very low counts say 8's to 12's, smaller top driving pulleys may be used.

Tin roller speeds get down to about 450, and spindle speeds to 5,000 for low counts of yarn.

The tin rollers may be four X tin ordinarily, and for long frames with motor on tin-roller shaft five X or six X quality of plates may be made for tin rollers. In these days of helical wheels, buffalo hide wheels, and vastly improved chain driving, it ought to be possible to drive one tin roller from the other positively, and yet with freedom from noise and breakdown.

Dead Weighting of front-top rollers, and self weighting of back and middle-top rollers, is the more common system for ring-frames $1\frac{7}{16}$ inch distance between back and middle rollers for American cotton and $1\frac{1}{2}$ or $1\frac{3}{4}$ inch for Egyptian cotton. One long round weight serves for one top roller on each side of frame, so that it weights two top rollers or four threads altogether. For shorter cottons some prefer to saddle, bridle, and lever weight all three lines of top rollers together.

Doffing Rods should run along the front of the rail so that doffing tins may be moved along them easily.

Tenters.—Ring-frame tenters in England are usually girls or women, paid sometimes by weekly wage and in other cases piece-work.

Two frames of 300 to 350 spindles each or 4 sides per tenter, average conditions and counts.

A good tenter will keep roller laps down, keep the rollers, lappets, and ring rails clean, change the travellers methodically, keep the roller weights acting properly, see that defective top rollers are changed, make good piecings of back rovings or of front broken ends, and see that slack spindle bands are changed.

In piecing broken ends it is customary to pull the bobbin off the spindle, find the end and hook it beneath the traveller, hold the bobbin firmly in left hand until it is firmly placed and the lappet is down, then piece up to the rollers. Care and practice are needed to piece up without making bad ends, more so than at the mule, because of the inclination of rollers and because winding is continuous with drafting and twisting.

Doffing.—Small boys or girls—as the case may be—move from frame to frame, doffing, piecing-up, and re-starting the frames. Doffing tins may be in two parts—one for full and one for empty bobbins.

In doffing, the tenter should first see that the frame is as neat as can be; then the doffing pin is removed, when the ring rail is descending, and the rail is rather quickly lowered by the long doffing handle. Ring rail at bottom for a moment—lower than base point of winding-on—permits yarn to coil below the bobbin on the spindle so that the bobbins can be plucked off without having the ends to piece up. Frame stopped just as ring rail reaches lowest point. Thread rails all lifted up, copping motion wound back to starting, bobbins removed and empties applied. Lappets all dropped, doffing motion replaced, frame started with ring rail up.

Continuously-varying Speed Motion and Two Speed Motion.—In the formation of a cop, the spindle is usually driven at a uniform speed, such speed being the maximum the yarn will stand without excessive breakage or inferior spinning. Higher speeds could be used when spinning on the bigger diameters of the cop, but as these would be too high for the smaller diameters, advantage cannot be taken of this fact. Higher average speeds and greater production could therefore be obtained if the spindle could be driven at a varying speed, which would at any moment be the maximum possible instead of as usual at a uniform speed, which is this maximum only during a small part of the formation of the cop.

Uniform yarn tension during spinning would greatly improve the quality of the yarn and make it possible to spin a softer yarn, but owing to the constantly varying diameter of the cop, the tension cannot be kept uniform except by variations of speed to counteract these varying diameters. There is, therefore, a double reason for desiring a constantly varying spindle speed. The importance of these variations depends on several factors, the chief ones being the spindle diameter and the softness of the yarn. In big diameter hard-twisted cops, the advantages gained by varying speed are minor ones, except during the formation of the cop bottom, but in small diameter soft-twisted weft cops this varying speed becomes of great importance.

The above has been recognised by ring spinners for some years, and an excellent electrical device was evolved by which this varying speed was obtained by variable speed electric motors being coupled to the frames.

These motors are very expensive, and can be used only in mills where electric power is available.

It is to meet these objections that the belt-driven continuously-

varying speed motion, which is below described, has been introduced. It enables ring spindles to be run at a higher average speed, and gives a uniform tension to the yarn, thereby increasing the production, improving the quality, and enabling a very soft yarn to be spun. This statement is subject to difference of opinion.

The motion works as follows:—

Fixed on the driving shaft is a cone drum, which drives another cone drum fixed on the driving tin roller shaft.

The belt is moved along the cones by a guider controlled by two quadrants, which get their motion from a cam driven by a pair of bevel wheels from the heart shaft. When commencing to build a cop the belt remains in one position, thus driving the frame at a constant speed. This goes on until the conical cop bottom is formed, then by means of a lever arrangement, the motion is put in gear and the belt commences to travel backwards and forwards along the cone drums, giving a spindle speed to suit the different diameters of the cop. The speed of spindles may vary from, say, 8,500 when winding on the smallest diameter, to 10,000 when on the large diameter. The arrangement is so made that the cam for working the lifter and the cam for moving the belt along the cones cannot get out of position when once set, thus ensuring that the slowest speed is always in action exactly when winding at the nose of the cop.

It is a well-known fact that after the cop bottom has been formed the spindle speed can readily be increased by about 1,000 revolutions without causing more breakage of ends, and with the advantage of a greatly increased production. By means of the motion illustrated, this is accomplished automatically, and the motion requires no re-setting after doffing.

The fast pulley is of two diameters, and the strap is moved from the large diameter to the small diameter at the finish of the cop bottom.

The strap is moved on the first speed by the starting lever, which brings the strap fork against a sliding bracket, which is locked until such time as the belt is required to be moved on the highest speed.

Fixed on the first poker is an adjustable bracket, which comes in contact with a lever hinged to the spindle rail; with every lift of the ring-rail, this lever is moved through a greater distance until it allows the long lever to come opposite the copping lever; when this happens the copping lever commences to lift the long lever and thus releases the sliding bracket and allows the weight to pull the strap on to the second speed.

Ring Rails and Rings.—Ring rails are made in short lengths and are planed and polished all over. They are secured in position by pegs fixed in the tops of the lifting pokers.

Before passing for use, rings are subjected to careful and thorough tests, in regard to concentricity, general fit, and hardness.

Traveller clearers are fixed to the ring rails. Either single or double tin rollers are applied to ring-spinning frames. The tin rollers are made from strong tinned steel plates and are carefully balanced and tested at works at higher than working speeds. Self-oiling bearings for tin rollers and ball bearings have been applied in some cases.

A flat foot is fixed to the poker, which rests on a bowl carried in the arm of the rocking shaft. When the ring rails are correctly set, the position of the foot is fixed by an adjusting screw with lock nut, in the bottom of the lifting poker. The pokers can therefore be lifted out for cleaning, and afterwards replaced without disturbing the height of the ring rails (see previous Fig. 90).

Size of Travellers.—It is impossible to give an exact rule for fixing the sizes of travellers required, as these vary according to the spindle speed, diameter of ring, turns per inch, and quality of cotton used. The following list may be taken as approximately correct when using American cotton. For Indian cotton a traveller three or four grades lighter, and for Egyptian cotton, a traveller three or four grades heavier will be required. See also other tables given herein.

Counts of Yarn.	Usual Diameter of Ring.	Size of Traveller.	Counts of Yarn.	Usual Diameter of Ring.	Size of Traveller.
	ins.			ins.	
4s	2	9	28s	$1\frac{5}{8}$	4/0
6s	2	8	30s	$1\frac{5}{8}$	5/0
8s	2	7	32s	$1\frac{5}{8}$	6/0
10s	$1\frac{7}{8}$	6	34s	$1\frac{5}{8}$	7/0
12s	$1\frac{3}{4}$	5	36s	$1\frac{5}{8}$	8/0
14s	$1\frac{3}{4}$	4	40s	$1\frac{1}{2}$	9/0
16s	$1\frac{3}{4}$	3	44s	$1\frac{1}{2}$	10/0
18s	$1\frac{3}{4}$	2	48s	$1\frac{1}{2}$	11/0
20s	$1\frac{3}{4}$	1	52s	$1\frac{1}{2}$	12/0
22s	$1\frac{3}{4}$	1/0	56s	$1\frac{1}{2}$	13/0
24s	$1\frac{3}{4}$	2/0	60s	$1\frac{1}{2}$	14/0
26s	$1\frac{5}{8}$	3/0	64s	$1\frac{1}{2}$	15/0

Weft Spun upon Ring-Frames.

In England at any rate the very general practice is to spin pin cops upon the bare spindle of the mule, which latter machine is not only better adapted to spinning the soft twisted weft yarns from a comparatively low quality of cotton, but is also beautifully adapted

for spinning upon the bare spindle. How far the growing tendency to adopt automatic looms will affect the problem of producing weft upon paper tubes or pirn bobbins remains to be seen. There can be no doubt that in other countries, such as the United States of America, ring-frame weft is produced on a far more extensive scale than in England.

Re-winding of cops upon hard cops or spools for the shuttle gains in favour, and special machines for this are made by different firms.

Speaking generally, shuttle weft spun upon the ring-frame may require a good deal more attention than warp yarn, because it is usually spun softer, and often from worse cotton. To meet these circumstances it may be wise to draft the more skilful of the operatives to the weft-frames, and pay more attention to heating, ventilating, and humidifying. Better cotton will, of course, readily make itself manifest in the spinning, but it may not pay a master to go too far in this direction. The tendency of recent years has been for the better qualities or "points on" of American cotton to become dearer and more difficult to obtain. It is more difficult on a ring-frame than on a mule to allow for variations in staple of cotton and in atmospherical conditions; and the general use of female labour for ring-frames as compared with male labour for mules is not in favour of producing ring-frame yarn from poor cotton and low twists per inch. It would appear that many weaving, printing, and dyeing establishments have adapted themselves to working with harder twisted wefts than formerly, and this, of course, makes it somewhat easier to produce ring-frame wefts.

Using rings of small diameter and paper tubes or wood pirns as large in diameter as the circumstances will permit, is one of the most effective methods of obtaining reasonably good spinning on weft-frames, but has the very serious objection of not allowing sufficient yarn to be put upon any one cop or bobbin. It is, of course, well known that with a comparatively great difference in diameter between the ring and the empty tube there is too much strain imposed upon the yarn in the latter dragging the traveller round the ring, and patented forms of traveller to diminish this evil have apparently met with little success, although invented and experimented with by the dozen.

For a great many woven cloths it has always been a desideratum to place as much yarn upon each weft pin cop as the size of shuttle will permit, and it has always been an everyday occurrence for weavers to complain that pin cops were slightly too thin or too short, and then at the next delivery of yarn to complain about the cops being too thick or too long for the shuttle. If an overlooker attempts to spin pin cops on the ring-frame even upon paper tubes, he must be prepared for trouble in the direction just indicated.

On the mule it is customary to shorten the top cone of cop just before doffing, in order to lengthen the cop cylinder, and thus get a trifle more yarn on each cop. It is not convenient on an ordinary ring-frame to obtain this particular effect, and therefore the overlooker must keep his pin cops as short in the top cone as circumstances will permit. The use of through tubes will perhaps facilitate this detail somewhat. Before re-using the through tubes or the wood pirns, it is advisable that absolutely all waste should be cleaned therefrom, as such may hamper the spinning. In cases of really bad spinning it will probably be found best in pin cops to run the lifter more quickly upwards than downwards, although this does not appear to be the best for the yarn coming off the end of the cop or bottom at the loom.

Frequently in the case of self-actor mules it happens that some of the twist mules are required to spin pin cops upon the twist $1\frac{3}{8}$-inch gauge, and usually this can be done with very successful results. Probably the real trouble in regard to producing weft upon ring-frames is when similar effects are required as from the mule, that is, when pin cops are wanted from twist gauge of spindle, twist diameter of ring, and other conditions which are very difficult to alter. The ring-frame is by no means as accommodating a machine as the mule when it becomes a question of making extremely wide changes of counts, twists, and different diameters of cops. To spin yarn on the ring-frame, using paper tubes $\frac{1}{2}$-inch diameter, is a much harder business than spinning it upon the same frame with tubes $\frac{3}{4}$-inch or $\frac{7}{8}$- inch diameter, using the same spindles and same diameter of rings. Some such cases have been partially met by substituting specially constructed rings with a less working diameter, but fitting the same ring rail spaces as the original rings.

Probably most pin cop weft is spun twist way, and nearly all thread and warp yarn is spun twist way. Frequently, however, pin cop weft is required to be twisted weft way, and the cloth would not take some dyeing and printing effects accurately if weft way yarn were mixed with twist way yarn in the shuttles. Reversing of the spindle bands and having the spindles revolving the opposite way is not quite as simple a matter on the ring-frame as on the mule, inasmuch as the snarl catchers and the traveller cleaners are not always certain to give the required effect when the travellers are dragged round by the yarn in the reverse direction, although often these will act correctly for the weft. In any ordinary case, of course, the spindle bands must be reversed.

Assuming that we are intending to spin the same counts of yarn in the weft as in the twist, it will probably be necessary to put on a larger twist wheel in order to reduce the twist per inch in the yarn, and for American cotton we might take for the weft $\sqrt{}$ counts

× $3\frac{1}{4}$, while for twist $3\frac{3}{4}$ up to 4. Probably we should need to put on somewhat lighter travellers for the same counts. It is not to be forgotten that spinning hard twisted weft would be tending to produce a harder and "barer" cloth, or one deficient in "feel" and "cover," besides making the cost of production of the yarn greater.

It should be possible to apply snarl catchers to suit both hands if the alteration is to be often required, but it would be perhaps better to cater for weft market requiring twist way of the spindles if weft is spun at all upon twist frames. If the weft is required to be bleached or dyed in the hank, then it becomes much more convenient to spin it upon a frame with twist gauge, and this may be even an advantage, because the cops will last longer in the reeling process.

If the pin cop weft is to be spun for direct use in the loom in the grey condition, then it is a matter of importance that the paper tubes shall properly fit the spindles at the ring-frame, and also the shuttles and shuttle pegs at the loom. To this end it may be advisable to send a sample ring spindle to the tube maker when the tubes are being ordered.

Referring to strength of yarn, it is seldom that weft yarn requires to be as strong as twist yarn of equal counts. In 1900 the author found that twist yarn from Brown Egyptian cotton was made stronger by twist up to a constant of 5. In 1918 he found that Sakelarides cotton was best with only 3·5 or 3·6 constant.

Spinning Weft on the Ring-Frame.

This question has always been more or less closely allied to that of spinning on the bare spindle of the ring-frame, since shuttle weft is often wanted direct from spinning machine to loom, and the empty tubes of a twist ring-frame are unsuitable for the shuttles of looms. For thirty years past the present writer has seldom passed a week without this question coming under discussion, and a very large number of experiments have been made in this direction.

Within the last few years efforts have been more directed to rewinding weft into very hard spools on weft winding frames of the spindle type, or else to spinning weft yarns upon small wooden pirns suitable for the shuttles of Northrop and other looms. Some people prefer this line of research or experiment, but efforts still go on in one quarter or another towards improving the ring-frame in spinning weft yarn and making weft cops. In America there is a tremendous weight of cotton weft spun on the ring-frame, but in England weft is yet spun infinitely more on the mule than on the ring-frame.

In building cops that have good cop noses and that will ready

well, in spinning yarn that is soft and will give good cover to cloth, and in getting good spinning with low twist per inch and moderate weft cotton, the mule beats the ring every time in Lancashire, where there are numerous and very competent male operative spinners. For some fabrics the harder ring weft appears best and is much used, but not so for the bulk of cotton fabrics.

In Whitehead's invention, as recently made by Messrs. Renshaw & Fallows, we have one of the latest weft ring spinning frames, for which it is claimed that it will spin weft yarns with only standard weft turns per inch (constant $3\frac{1}{4}$ for American and 3·183 for Egyptian), up to 200's counts or finer if so desired. A small machine has done practically this count of yarn from 24-hank roving.

In this new ring-frame, instead of a fixed ring, a patent carrier is introduced, formed at its upper edge like an ordinary ring, except that it rotates around the spindle.

To compare with an ordinary ring-frame with a spindle making 10,000 r.p.m. the traveller would perhaps make 9,500 or more, the traveller revolutions representing the number of twists put in the yarn, while the difference in revolutions between spindle and traveller represents the winding-on revolutions.

In the new arrangement under notice the ring or carrier revolves in same direction as the spindle, and their respective revolutions may again be taken at 10,000 for spindle and 9,500 for the revolving ring or carrier. In this way the traveller drag is practically done away with, this being an important advantage, since the traveller and carrier have practically equivalent speeds.

Two pairs of tin rollers are used as in the "false twisting frame" for coarse yarns, as against the one pair of an ordinary ring-frame.

One pair of tin rollers is placed above the other.

Bad Spinning at the Ring-Frame.

It has often happened at the same firm that the mules could be kept nicely going when the ring-frames have practically come to a standstill when both have been using the same sort of cotton from the same mixing, and both spinning the same counts, or the mule even a trifle finer than the ring. It frequently happens that the youths, girls, and women who have charge of ring-frames are scarcely so competent to face bad spinning conditions with the ability that self-actor minders display at the mules. Neglect in keeping the top and bottom rollers clean, under clearers properly picked, oiling and cleaning efficiently performed, broken threads promptly pieced again, or creel bobbins changed at the correct time, will often add to the troubles when the cotton is a little

worse than usual. In cases of bad spinning these need attention even more so than with good spinning if progress is to be made at all.

While the operative should have extra regard to these points in cases of bad spinning, it is incumbent upon the jobbers and overlookers to go through the frames with regard to special adjustments which are somewhat outside of the ordinary duties of the tenter.

The overlooker should see if the bobbins cannot come to the ring spinner in a better condition, and more free from such defects as slubs or bad ends, "thick" and "single" portions of roving, ends run over the ends of the cones, or rovings of variable counts. Then he should see that the top and bottom draft rollers are not only satisfactorily cleaned and oiled, but are properly adjusted centre to centre, according to the class and staple of cotton in use. It should be noted that the top and bottom clearers are acting efficiently, and that the roller weights are accurately suspended upon the rollers, roller traverse motions properly working, fluted and channelled top rollers promptly taken out, the counts of yarn kept as coarse as is permissible, with twist as high as may be allowed. These are items that may possibly receive attention in any extreme case. Although the inclination of roller stands may appreciably affect this problem of bad spinning, yet we must make the best of this, as we cannot conveniently make any alteration.

The question of concentricity of spindle with ring and of thread wire with spindle is a matter also for the officials in charge, and the former should be tested and rectified by the aid of a gauge. Equally a small gauge of another description may afterwards be placed on the spindle, with a sufficiently long pointer extending upwards so as to clearly show whether the thread wire is in centre with the spindle and ring.

In cases of extremely bad spinning we should consider whether lighter travellers could be used, or whether renewing the travellers by new ones of the same counts will bring about any improvement. Since the traveller is dragged round the ring often at the rate of about 1,700 yards per minute, it follows that both traveller and ring need to be in good condition when the cotton or the atmospherical conditions are scarcely as good as they might be. Considering what a very light instrument the traveller is, it appears rather curious that in process of time it will appreciably wear the hardened steel rings—so hard at first that really good files cannot touch them—but experience has proved in numberless cases that such wear does take place. The lower side of the inside flange appears to be most liable to wear, owing to the effect of centrifugal force on the yarn and the traveller, and if this be rough or wavy, we may be forced to renew the rings before satisfactory spinning is obtainable, in spite of the necessary expense.

Sometimes a good burnishing of the rings will effect an improvement when they have been allowed to cake or clog somewhat with dirt of some kind. Cases have been known where the application of more modern anti-ballooning apparatus, or separators, has enabled lighter travellers to be used, and has made the spinning quite satisfactory.

Possibly re-varnish the front leather rollers. Sometimes the fluted iron rollers become injured by the use of steel or iron pickers, and such rough places necessarily tend to break certain threads excessively. Brass pickers are preferable as being less liable to injure the rollers. Hitting roller laps with top clearers is a sure way of bringing trouble later on. Not only is it necessary to have each spindle concentric with its ring, but the spindle bands should be kept at a reasonable and uniform tension. Spindle bands that are all right in tension when put on during a period of dry, hot weather may become altogether too tight in wet weather, while this rule also works the reverse way, so matters of this kind are not beyond consideration in cases of bad spinning. Vibrating spindles are, of course, directly opposed to good spinning, and any such vibration should be checked by re-oiling the spindle, changing the empty bobbin, or noting that the "cigar" or inner tube is properly held in position inside the spindle. As a general rule for average American cotton it has been found in practice best for fluted iron rollers to be taken out and scoured, and necks and squares thoroughly cleaned every three months. Under clearers, thread boards, ring rails, and other parts picked or cleaned four or five times per day.

Improper distances of centres of top and bottom draft rollers greatly affect the spinning, wide settings leading to weak, uneven yarn, while too close ones may lead to "spewing" of the cotton, breaking of fibre, and possibly to "crackers." Improper setting of top-front roller in regard to best position upon front bottom one may cause bad spinning. Want of lubrication and cleaning of rollers —especially top ones—defective leathers, imperfect action of the roller traverse motion, and other points affecting the draft rollers are prolific causes of bad spinning.

Rough places on the fluted rollers caused by pickers, thread wires out of centre with spindles, worn rings or travellers, travellers of wrong count for the yarn, are other very likely causes of excessively bad spinning, and there are proper methods of testing these points. Defective spindles are fruitful causes of bad spinning, and care should be taken not to have these strained or short of lubrication, or working with the inner tube turning more or less. The creel rovings must be in every way suitable to get the best results. As regards routine the bearings of front bottom rollers may be oiled three times per week, middle and back lines once per

week, front top rollers once per week, tin roller bearings and bearings in frame ends once per week, and to be kept supplied with grease or tallow in the grease cups. Gearing cleaned and re-greased occasionally. Fluted rollers taken out and scoured thoroughly perhaps once in three months, although these times vary. During scouring thread wires, rings, and other features to be examined. Under clearers and top rollers to be picked at regular intervals. Spindle bands to be kept in good condition. Generally speaking the chief factors which make for the best quality and greatest production of yarn are good rovings, moderate drafts, well-set and well-conditioned rollers, spindles, and rings, efficiency in regard to cleaning and oiling, well-balanced twist per inch, well-graded travellers, careful and skilful operatives and foremen.

Defects in Ring-Frame Work.

(*a*) Hard and wiry yarn upon a few bobbins only may be due to defects either in the back creel bobbins, or in the rollers, or in making double yarn. Hard portions in the rovings or too coarse rovings will give hard yarn. Rollers binding through being dirty or short of oil will give hard yarn. A broken creel bobbin entering the wrong guide tin or a broken front thread joining rollers to the next spindle will give hard yarns. Set too closely and causing spewing may give hard yarns. Excessive twist may affect this.

(*b*) Soft yarns may be due to slack spindle bands, binding of spindles and cigars, vibration of worn spindles, unbalanced bobbins, or sticky poker bars. Insufficient twist in the yarn, single in the back bobbins, irregular rovings, one end instead of two going upon a bobbin.

(*c*) Frequent thread breakages on certain spindles may be due to thick or single rovings, dirty, dry, channelled or fluted leather rollers, dirty iron rollers or roving guides, roving traverse set wrongly, wrong size of traveller, blunt skewer, worn rings or travellers, traveller clearer set too near the ring, spindle and ring not concentric, thread wire rough or worn, not over spindle point or set too low down, roller weight wrongly placed, worn roller hooks, binding cigars or spindles, vibration of spindle or slack spindle band.

(*d*) During descent of ring rail there is a tendency to tighten the threads and especially when the descent is quicker than the ascent. Defective quality of cotton, irregular rovings, travellers too heavy, too low a twist constant, too great a lifter speed tend to develop this evil and cause bad spinning.

Mechanical Bobbin Stripper.

There is a type of mechanical bobbin stripper adapted to remove the small portions of roving left on the tubes or bobbins from the creels of ring-frames or mules.

In one example under the writer's notice the piecers willingly carry the bobbins to a different room to get the benefit of such a machine, and the management profit by having fewer cut and damaged bobbins, which during and since the war became very expensive and for a time difficult to get prompt delivery of.

These roving bobbins are placed lengthwise and horizontally upon a pair of suitably revolving rollers, the loose ends of roving are directed to the bite of the rollers, the roving is unwound by frictional contact and passes into a suitable receptacle. High prices of raw cotton, roving, yarn, and new, empty tubes or bobbins, favour the adoption of mechanical bobbin strippers.

A well-known type of stripper for ring bobbins is arranged with a vertical spindle on which is placed the bobbin.

A forceful turn at a handle draws a scraper over the bobbin and takes the waste cotton off.

(*a*) *Working of Ring-Frames.*—In regard to the spindle bearing, it should be of good length, and well arranged to resist firmly any pull of the spindle band. Re-oiling should be easy, and it should not be possible for loose fibre or dust to get at the bearing. The combined footstep and bolster bearing is universal.

(*b*) Good fitting, well-balanced bobbins are very important, and it is better for a bobbin to bite at the let-on or upper part of the bobbin, rather than at the bobbin base on the spindle sleeve. A good "let-on" bite prevents creeping or working upwards of bobbin.

(*c*) Five inches lift is very common, but 6 inches, 7 inches, and even 8 inches lift for coarse yarns are all more or less in use.

(*d*) On a ring-frame the twist always exercises more or less of a shortening effect on the yarn and makes the yarn of somewhat lower counts, so that more than calculated draft is required. On a mule the carriage travel resists the shortening effect of twist, and when "gain" or "ratch" is put, the roller draft must actually be less than given by a calculation which ignores these factors.

(*e*) Tests readily show that the tin rollers and spindles absorb most of the power; then the draft rollers and their work, the rest being absorbed by gearing and minor motions.

(*f*) Most ring-frames are without any special speed-varying mechanisms. When such are applied one aim is to run more slowly when winding upon small diameters of cops or bobbins, and more quickly for larger diameters.

(*g*) One radically different method of driving ring-frame spindles that has been devised, consists in using an endless flat steel flexible

band, running alongside the spindles, and driven from a pulley on a vertical shaft at the frame end. Perforations in this steel band receive suitable projections on the collars of the spindles.

(*h*) It is sometimes desired to polish and clean the rings of doubling and spinning frames, and this may be done by hand on the frame itself, or the work may be done by mechanical means.

A revolving brush may be driven from the tin roller of the ring-frame. A friction disc is driven from the tin roller, and by means of a short flexible shaft and bevel wheels a suitable brush obtains a high speed, and is held in the rings and quickly gives a good polishing effect.

(*i*) Guards are now frequently applied between the two tin rollers on the under side, to prevent accidents by the arms of the operatives being drawn in. In many cases the tin rollers are driven the other way in order to remove the possible cause of accident even if no guard is used. On some frames it is possible to reverse the frame drive and then reverse the spindle bands to obtain same twist way as before, and to change the top twist wheel drive from one side of frame to the other. Special band threading rods are sometimes used to help in applying spindle bands when guards are used as this banding then becomes troublesome. In some examples of tin roller guards the placing of the main belt on the loose pulley to stop the frame, moves the guard away so that bands may be applied.

(*j*) *Clutch spindles* are in use at some mills, and require attention in regard to maintaining at all times and for all bobbins a satisfactory bite when working, and prompt release when frame stops.

A series of segments are fixed in the sleeve of the spindle, the upper parts of said segments being free and having a tendency to fly outwards and grip the inside of the bobbins when frame is working. Stopping of frame stops the centrifugal force and releases the bobbin. When in good condition and correct bobbins are used these clutch spindles make it distinctly easier to remove the bobbins at doffing time. A ring jobber should see that the conditions are kept good when using clutch spindles.

The amount of expansion of the clutch segments is limited by a ring, so that too much "bite" shall not be imposed on the inside of the bobbin.

(*k*) *Rope Driving of Tin Rollers.*—Except in the case of yarns requiring to be very uniformly twisted—such as good thread yarns—methods of rope driving of one tin roller from the other are not much in favour with practical men. Thirty or forty ropes of this kind add to the labour of the jobbers, they sometimes break adjacent spindle bands when unravelling, and they add to the driving weight of a frame. The loss of twist in the negatively driven side of the frame in many cases is not considered much of a defect. There

are some firms, however, which prefer the rope driving. One spindle one spindle band is the favourite method, but one spindle on either side of frame is driven by some from same band. Double tin rollers keep the bands at the bottom of the spindle warves and are more used than single tin rollers.

(*l*) Ring traveller *magazines* are used in some places and prevent travellers from locking and fastening together. A holder or magazine may be fixed on a convenient bench or table and a bunch of travellers at a time placed in the receiving box. The contrivance is such that the travellers leave it singly.

(*m*) *Oiling of Spindles.*—Two contrivances are largely used in connection with the oiling of ring-frame spindles, which is a much bigger job than on a mule, but needs to be done very much less frequently on the ring-frame (see p. 381).

1. The oil extractor is a small hand pump by means of which the old oil is drawn out of the base or holder of the spindle and into the body of the pump for subsequent emptying. When spindles have removable oil cups at the foot of the holder this pump is not necessary.

2. The other oiling device consists in a specially large and specially shaped oil-can which is arranged to pour a measured amount of oil into each spindle bearer. As part of the large oil-can, there is a suitable nozzle or oil spout, a small force-pump operated by the thumb of the operator, an adjusting screw for regulating the amount of oil given out by one action, and a sight-feed for the operator to notice the working of the appliance.

(*n*) For some years it has been possible to obtain appliances for stripping yarn left on the so-called empty tubes, after the general style of a drawing-on machine in roller covering. The bobbin is placed in position, and a pair of spring jaws drawn rapidly and firmly along the bobbin so as to force the yarn off.

(*o*) *Hank Rovings.*—The following have been recommended for ring spinning. Single roving from American or Good Indian cotton :—

Counts of Yarn.	Hank Slubbing.	Hank Intermediate.	Hank Roving.
12's to 20's	·6	1·2	2·75
16's to 24's	·6	1·5	3·5
24's to 32's	·7	1·75	4·5
36's to 40's	·8	2	5

(*p*) *Frame ends* and spring pieces are best made with loose feet for adjustment to uneven flooring, so that every bearing can do its share even if there is shrinkage of wood,

(*q*) *Case-Hardening.*—The necks of all the steel rollers should be case-hardened and especially the front line. Many people prefer to pay the extra cost of front line being case-hardened all over to prevent damage to flutes by use of iron pickers for roller laps, or hitting rollers with top clearers. It has been argued that case-hardened rollers are somewhat harmful to the cotton fibres, but it is hardly likely they can be more so than mild steel rollers, and the contention hardly agrees with tests coming under the observation of the present writer.

(*r*) *Roller Covering.*—Modern roller covering appliances have much diminished the chance of the two bosses of one roller being of different finished diameter, but for all that most people prefer to be on the safe side and pay the extra cost of loose boss front rollers for ring-frames. Roller ends should be dotted as a guide to coverers and users in keeping all leather piecings the correct way.

Ring-Frame Traverse Motions.

The plain single eccentric motion is still largely employed. About 1893 Mr. George Paley, of Preston, apparently started the ball rolling in the direction of compound eccentric traverse combinations arranged more especially with a view to providing variable traverse motions. Shortly afterwards several other of these compound motions appeared on the market, such as Hurst and Fenton's, followed by Cook and Harrison's. As a matter of fact, all these three types have been extensively adopted, and are being regularly made by one firm or another, and with but slight alterations in construction or action. Paley's motion has always been one of the neatest and most effective of these variable traverse motions, and a brief description will be of profit to many readers since it is much used on fly-frames and mules, as well as on ring-frames.

Practically all roller traverse motions are operated from the extended spindle of the back steel draft roller, and Paley's motion is no exception to this general rule. It presents the outside appearance of a neat circular box with little mechanism showing beyond the worm fixed on the back roller, gearing equally with two worm wheels carried on a central stud. The motion is worked upon the Hunter cog principle, the two worm wheels differing in size by one tooth, as for example, containing 24 and 25 teeth respectively in some of the earlier motions, but capable of being made with other numbers of teeth, and actually containing 40 and 50 teeth respectively in some of the more recent makes.

One of the two worm wheels is cast with an extended boss which forms an eccentric fitting loosely upon the central spindle. This first and smaller eccentric is loosely encircled by a second and larger eccentric which is connected by a pin and slot arrangement

with the second worm wheel. The eccentric strap of the traverse guide rod envelops the outer eccentric and receives its reciprocal and lateral traverse therefrom. It is possible for the full portions of both eccentrics to be working together, or for both thin portions, or for the opposite extreme of the thinnest portion of one eccentric to be working with the fullest portion of the other, or any intermediate positions to be assumed. With both full portions together the traverse attains its maximum extent; with both thin portions there is the minimum traverse, or any intermediate size of traverse is obtained. The consequence is that the amount of traverse is always varying, giving the very great benefit of the point of traverse reversal continually taking place on different portions of the leather. This is a fine preventative of channelling of the leathers. Taking the very mild example of 24 and 25 teeth respectively in the worm wheels, and starting at the minimum traverse, then it would take 25 traverses before the maximum had been reached, and then the traverse come back to the minimum. This number would be doubled in the more modern combination of 49 and 50 teeth.

These compound traverse motions appear to show up to especial advantage in such cases as the spinning of hard twist upon the ring-frame or mule, such material being more likely to channel the leather rollers than ordinary twist yarns.

Hurst and Fenton's Traverse Motion.

This differs radically from Paley's in construction, operation, and in the nature of the traverse imparted. It is argued against Paley's that the traverse, however short or long at any one time, always crosses a central point of the leather, but this is not true of the rival motion.

Regarding the construction of the " Champion " traverse motion, there is only one worm wheel gearing with the worm on the end of the back steel roller. Upon the under side of this worm is cast a small triple cam for giving the traverse, so that for one revolution of the worm wheel, three of the short traverses are obtained. Upon the upper side of horizontally disposed worm there is also a small spur wheel, which slowly drives a larger spur wheel sustained upon a second upright stud. This worm wheel is compounded with an eccentric upon which is swivelled a loose finger which comes against the aforementioned triple cam. The end of the traverse rod comes against this loose eccentric finger. Every revolution of the worm wheel gives three short traverses to the rovings across a small portion of the leathers, say starting near one end thereof. The much slower rotation of the eccentric gradually moves the loose finger farther across, farther away from the centre, so the short equal traverse takes place over a different length of leather. The

points of reversal of the traverse are always being altered by the eccentric on the large driven wheel, although the change is so extremely gradual as to be almost imperceptible for a moment. Let it be understood that the Paley motion gives a traverse which actually varies in extent from minimum to maximum, and back again, and in this way is variable. The Hurst and Fenton motion produces a variable traverse of a totally different character. This extent of traverse does not vary, but is always equal, although any one traverse is extremely short. Starting at the limit for one end of a roller, it has its full traverse there, and by and by will be giving the same amount of travel, but at the opposite end of the leather roller. There is no doubt that these two earliest of the variable traverse motions added to the wealth of useful mechanical combination possessed by the cotton spinning trade. It is to be regretted that very many of our foremen do not appear to sufficiently understand the new motions so as to always obtain the maximum amount of benefit from their use. There is no denying they are more complicated than the ordinary simple forms of roller traverse motion.

Cook and Harrison's Motion.

Briefly, a single worm on the front roller drives simultaneously into two worm wheels which differ one tooth in size, so that when the smaller wheel has made a full revolution the larger wheel is one tooth short of a revolution. The flat sides of the two worm wheels come together, and on the outside of each worm wheel there is an eccentric. A separate eccentric link envelops each eccentric, and each link is connected with the traverse guide at the other end. If both eccentrics have their full faces pointing exactly the same way the maximum thrust or pull is given to the traverse guide, but if the full side of one and the thin side of the other are pointing together, the traverse is, of course, greatly diminished in extent, with various extents of traverse for different combinations of the cams. Experience has demonstrated this to be an effective motion, and especially when properly adjusted and maintained in good working condition. Slackness in the studs, loose fixings or screws, or attempts to obtain a larger amount of traverse than is permissible by the width of the rollers, do not conduce to the best results, neither with this or any other traverse motion.

Coulthard's Motion.

This is an example of a totally different traverse, constructed upon a different principle than the three special motions previously described. It is much more like the D. and M. or Dronsfield and

Musgrave motion, for which the following advantages are claimed: "Positively regular, no dwell, hollowing reduced, and channelling impossible, saves cloth and leather, rollers last longer, easily fixed, and any length of traverse secured in an instant."

In Coulthard's motion there is only one worm wheel, driven as usual by a worm on the end of the roller. This worm wheel is pinned to the central and eccentric stud. The outside of the traverse box is plain, and very neat, but it conceals a rather ingenious wheel combination, one part being an internal wheel cast on the inside of part of the box. The special object sought does not appear to be the same as in the case of the other three motions described, that is, to obtain a variable traverse, but effort is apparently more directed towards securing a comparatively quick changing traverse, without the well-known dwell and channelling of the rollers at the reversing point.

Why Do Top Rollers Channel?

The question of circumferential nicks or channels being formed in the leather-covered top rollers is, of course, closely allied to the subject of traverse motions. It is a primary duty of roller traverse motions to eliminate as far as possible the formation of such channels, but perfection does not appear even yet to have been attained. Apart from any detailed argument, it certainly appears to the writer that variation at the reversing point cannot fail to be a good principle of itself, so long as the mechanism does not carry with it corresponding disadvantages. Quite recently a case came before the writer's notice, in which channellings regularly and frequently occurred in the rollers, no matter what so-called remedy was applied. Setting rollers wider apart, trying ing bobbins with less twist in, and re-covering of the leather rollers were all tried without a real cure, and only by the adoption of all known preventives have the rollers been made to work at all reasonably well in this respect. And yet similar rollers would work in other machines at the same firm with no such trouble at all. Equally the writer has known halves of certain mules to be guilty of fluting the leather rollers in the course of a few days, and this matter to go on in spite of every effort. While fluting and channelling are generally curable by ordinary remedies, there often have been cases of a distinctly puzzling and vexing character.

Waste from Mules and Ring-Frames.

There are not many varieties of waste made on either a mule or a ring-spinning frame as compared with the different kinds obtained from a card-room. Under clearer or crow waste is an important item and only differs in comparatively small detail as

between a mule or ring-frame. On a fine mule it is more usually formed on the long fluker rods which are fixed some distance below the iron rollers, but on ring-frames and all except fine mules it is formed on short flannel-covered wood clearers, which are held by springs against the front bottom roller. Such waste is usually soft, but is depreciated in value by having many hard threads wound in with the soft waste. Top clearer waste is another class, and is usually of less value than the above, as it mainly consists of loose fibre rubbed off the leathered-covered rollers. There is, however, much in common between these two classes of waste. Bobbin waste is another distinct and fairly large class of waste produced on final spinning machines. It is of good value, free from hard waste, clean, and is often put through a special bobbin waste breaking machine. Sweepings is the worst kind of waste, and as first swept up contains portions of almost all the other kinds of waste, but is at once roughly divided out into clean and dirty waste. The hard wastes come off the spindles, and may consist mainly of spinner's hand waste and pieces of pulled cops. Nicked cops, soft cops, pulled cops, and cops spoiled in other ways constitute a portion of the waste. The total percentage of waste varies considerably with the operatives and the kind of spinning, but assuming it to be 2 per cent., the clearer waste might represent about 1 per cent., the bobbin waste $\frac{1}{4}$ per cent., the sweepings $\frac{1}{4}$ per cent., hard waste and spoiled cops representing the rest. Spoiled cops should fetch almost the best price, and are often used again for making ropes and spindle banding. Bobbin waste is not of much if any less value, and is passed through a waste breaking machine, and then mixed again with raw cotton at the same or another mill. Clearer waste is of less value than the above, and is often used up again in proper cotton waste spinning. Hard waste is almost always passed through a hard waste breaking machine containing several cylinders, made into condenser waste yarn, and woven into various classes of goods. Even sweepings are generally passed through waste breaking, carding, and spinning machinery, and manufactured into candle-wicks, lamp-wicks, and similar articles.

Specification for New Ring-Frame.

The bottom rollers would be front and back rollers 1-inch diameter, middle roller $\frac{7}{8}$-inch diameter. Distance centre of front to centre of middle roller for ordinary American cotton $1\frac{1}{16}$ inch increasable to possibly $1\frac{5}{16}$ inch or more, the front and middle distance being most important. We should prefer dead weighting for front top roller, and self weighting for middle and back top rollers giving $\frac{7}{8}$ inch or $1\frac{3}{16}$-inch diameter when covered to front top

roller, $\frac{3}{4}$ to $\frac{7}{8}$ inch to middle top roller, and 2 or $1\frac{3}{4}$ inches to back top roller. Loose boss top rollers to front line 25° inclination of roller stands. Plain rollers to other two. Twist per inch $\sqrt{36} \times 3\frac{1}{2} = 6 \times 3{\cdot}5 = 21{\cdot}0$ turns per inch. About 7,800 r.p.m. for the spindles. Assuming the yarn is intended to be reeled and bundled or taken from the bobbins in any way before using as weft, we might stick to the standard 5-inch lift with a $2\frac{1}{2}$-inch gauge and $1\frac{1}{2}$-inch ring, but more likely dimensions for weft would be 5-inch lift, $2\frac{1}{4}$-inch gauge, and $1\frac{1}{8}$-inch ring. The hank roving should be arranged to give a total roller draft of not more than 7 to 8, say in this case, $4\frac{3}{4}$-hank. The production will necessarily vary with local circumstances, but may be taken at about 40 hanks per spindle for a decent full week, and favourable cotton. The distance from top of bobbin to centre of thread wire may be $1\frac{3}{8}$ or $1\frac{1}{2}$ inch, and from thread wire to nip of rollers may be about $4\frac{1}{2}$ inches.

Measuring Oiler, for Lubricating the Spindles of Ring-Spinning Frames, Doublers, and other Similar Machinery.

This oiler has been devised for the purpose of facilitating the process of oiling the spindle and other bearings of machines which require a certain measured quantity of lubricant to each bearing.

The advantage of this oiler will be too obvious to require any explanation.

The oiler holds fully one quart of oil, it is provided with a vertical force pump, the piston of which is pressed down by the thumb of the operator. This should always be pressed to the bottom.

The amount of each discharge of lubricant can be altered, if required, by adjusting the screw sleeve under thumb-piece. There is also a *sight feed* attachment to the spout, to enable the operator to see that the oiler is doing its work properly.

The material of which it is made is all brass and gun metal, and the workmanship is good.

This oiler has been improved so that the pump, with its valves and spout, can be taken out by unscrewing the screws which secure the round plate to the top of cylinder. This is to enable the valves, etc., to be examined, cleared of obstacles, repaired or renewed, without having to take the whole to pieces.

Extraction Pump for Spent Oil. Ring-Frames.

This pump is for the purpose of extracting the old spent oil from the bearings, to clean out before re-oiling.

It is used by inserting the pipe into the spindle socket, step or

FIG. 92.

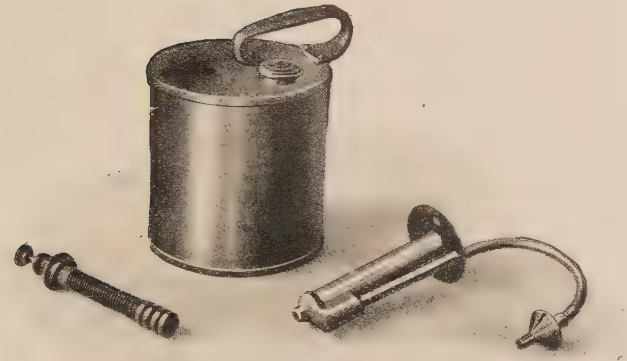


FIG. 93.

FIG. 94.

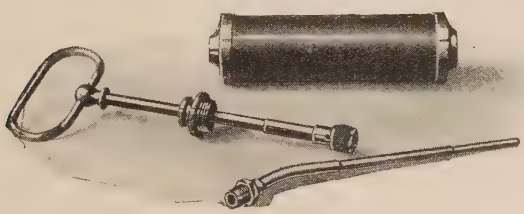


FIG. 95.

oil receptacle, holding in that position and working the piston up and down by the handle. The dirty oil is thus transferred to the main barrel or cylinder of the pump, which is emptied by taking out the screw under handle.

The material is brass all through.

Effective and easy to work, and holds much spent oil, etc.

Its simplicity of construction permits of it being thoroughly cleaned, with a minimum of trouble.

The Building Motion.

The builder motion of a ring-frame is naturally very different in mechanical detail from that of a self-actor mule, although an advanced student can trace the same fundamental conditions and requirements in many of the details. The heart cam, for example, takes the place of the mule copping rail, the cam lever takes the place of the locking lever, the chains, levers, pokers and ring rails of the ring-frame fulfil much the same kind of duties as the faller shafts and faller wires of the mule. Naturally, there is some little difference in detail as between different machinists, but they are sufficiently alike for a general description of one particular make to serve all the purposes of this article.

The Driving of Building Motion.

Starting with the driving, it is customary to arrange for the heart cam to be driven in a manner which permits the size of twist wheel to control the speed of the lifter. For example, in a particular case the twist wheel drives a large carrier wheel, which gears with and drives the large front roller wheel. On the same stud as the large carrier is a worm which drives a worm wheel fixed on upper extremity of an almost upright shaft. On the lower extremity of this inclined shaft is a small bevel which drives the large heart cam wheel, so in this way a sufficiently slow rotation is given to the cam. It will be noticed that in a case of putting on a larger twist wheel and speeding up the rollers to obtain a reduced amount of twist in the yarn, the same change will also equally speed up the traverse of the ring rail to spread the increased delivery of cotton along the bobbin.

As a matter of detail it may be pointed out that in another make of ring-frame the bevel wheels are placed at the top of the upright, while the worm wheel arrangement is transferred to the lower end of the upright—a mere matter of re-arrangement which exercises little effect on the practical working. In this latter case exact dimensions are as follows: An 18's bevel compounded with the 140's carrier drives a 25's bevel on top of upright shaft, and on

lower end of this shaft is fixed a double worm which drives a 58 worm wheel. Compounded with this 58 is the so-called heart cam, whose rotation alternately depresses the long lever of the copping motion, and then permits the same to move back again. If a clutch were used on the almost upright shaft it might serve the purpose of disconnecting this shaft from the wheel gearing or front roller connections to permit free turning of the shaft by means of a handle. The clutch is, however, more likely to be applied to a doubling frame than a ring-spinning frame.

The Shape of Cam.

It is common to apply the term heart cam to the copping motion cam, but as a matter of fact, it is not usually anything near the heart shape on a ring-spinning frame, although very frequently it is so on a doubling-frame. The heart shape produces equal speeds of up and down traverses of the lifter, but this is seldom found best adapted to bobbin building on a ring-spinning frame. We have stated that the copping cam practically occupies the same position, and performs the same functions on a ring-frame that the copping rail does on a mule. On the mule it is invariably the case that the copping faller wire descends in about one-fourth the time required for the ascent of this wire, and substantially this practice is found to give the best results also on the ring-frame. The explanation is that we obtain crossing threads which keep successive lengths of thread separated, and good readying cops are produced. Dividing the periphery of the copping cam into three or four equal parts as the case may be, we only have one part representing the movement of the ring rail one way, that is, in from one-fourth to one-third of the revolution of the cam the throw is sufficient to move the lifter through its entire length of traverse one way. The remaining portion of the periphery of the cam is devoted to bringing the ring rail back again in a proportionately slower manner.

In this connection the ring-frame possesses an important advantage over the mule inasmuch as it is quite easy to have the quicker movement of the ring rail either up or down, whereas it is always downwards on the mule, and cannot very well be altered. For the most part it is found best on the ring-frame to imitate the mule in this respect, and have the open or crossing threads placed on the cop or bobbin during the down movement of the rail. On the whole this apparently suits most people, and there is a feeling that it tends to give better cop noses, and if anything a better unwinding under average conditions. The quick down movement has one serious disadvantage which shows up most in the case of weak yarns, whether the weakness be due to soft twist or poor

cotton ; in such cases there is a decided tendency to pull threads down as the rail is moving downwards. Anyone familiar with a ring-frame knows that the up movement of the rail tends slightly to ease the threads by approaching the rail nearer to the rollers, whereas the recession of the rail from the rollers on the down traverse tends slightly towards tensioning the threads. This latter tendency is sometimes sufficiently marked in the case of weak yarns to render it advisable to have the slower movement downwards, so that the tightening effect of the recession of rail from rollers shall only take place in a very gradual manner. In frames constructed during the last fifteen years or so it is usually quite easy to change from one to the other, and as a matter of fact all that is needed in some cases is simply reversing the cam by taking it off and putting it on again the other way about, a matter of a couple of minutes, and involving no further change. The particular features we have just discussed apply, of course, to the ordinary cop-shaped bobbins, and these are required in probably nineteen cases out of twenty from the ring-frame, being quite suitable for the ordinary purposes of winding upon cheeses or warper's bobbins, reeling into hanks, or in the case of shuttle weft built upon paper tubes.

Roving Bobbin Shape.

There are some cases, however, in which it is required to produce bobbins upon a ring-frame after the manner which is universal upon slubbing or roving frames, i.e. with equal coned ends and the first layer of yarn traversed from end to end of the bobbin. Afterwards, in a very gradual manner, the lifter traverse is shortened in a very small degree at the end of each traverse from start to finish of the set of bobbins, producing the well-known double equal cone effect. There are many people who deem this method the better one when the yarn has to be unwound from revolving skewers or spindles in the same way that rovings are drawn off in the ring-frame creel, and so as to produce hard, well-filled warper's bobbins. A little reflection will convince anyone that side unwinding from cop-shaped bobbins will require the bobbins to turn faster when unwinding from the apex than when drawing off the base of the cone, and such varying speeds are not as conducive to making good warper's bobbins as they might be. In the case also of extra twist yarn, which has a distinct tendency towards snarling, it is often deemed best to reel from revolving spindles and from bobbins built upon the roving-frame principle, although good results may possibly be obtained by reeling over the end of cop-shaped bobbins, and drawing the thread through some such anti-snarling device as " Noton's " circular brush.

Remarks on Cams.

After the lapse of a few years it is quite possible that the copping cam may have become worn at the nose, or at the thinnest portion of the cam, so that the reversal of the lift is not as prompt as it might be, and although the use of bobbins to place the yarn upon prevents very serious results, yet it will be none the worse for a little expert attention upon the part of those in charge of the machines. The cam ought always to be kept nicely greased, and the same with regard to the worm and worm wheel gearing for driving the cam. For the benefit of absolute learners it may be stated that the cam always revolves one way, and its action may be well compared to that of the cam in a plain roller traverse motion. The rotation of the cam alternately depresses and permits the raising of the copping lever which is connected on the one hand to the chains, levers, and pokers of the lifter rail, and on the other to the shaper wheel arrangement.

The Long Copping Lever.

It is necessary now to trace the manner in which the continuous slow rotation of this cam is made to move the ring rail about. The usual method is for the full part of the copping cam to depress the long central lever of the copping motion, and to have a chain and lever combination by which the lowering of the copping lever forces the ring rails upwards. To take a particular frame, the end of the lever farthest removed from the fulcrum is constructed to hold a small chain block, the shaper wheel, a worm and worm wheel arrangement for turning the chain block, and a small wheel connection for the shaper handle to wind the motion back again at doffing time. The depression of the lever draws chain from an upper chain block, and gives the latter a slow rotation so as to draw a second chain upon a companion block. This second chain draws at a lever bolted to a rock shaft reaching across the width of the frame. Extending outwards from the shaft are arms carrying small bowls upon which certain of the upright pokers for carrying the ring rails are supported. By a simple extension of the number of cross rock shafts, with their accompanying chains, rods, and levers, any length of frame, and any number of pokers may be provided for. As before stated, the depression of the copping lever forces the ring rails upwards, both sides of the frame at the same time. The weight of the ring rails—especially when also carrying the separators—is usually more than sufficient to give a definite and solid return of the parts and lowering of the rails when permitted to do so by the coming round of the thin part of the cam. As a matter of fact, it is often the case that balance weights are

attached to the cross levers beneath the frame in such a manner that they provide somewhat of a counter poise to negative some of the weight of the ring rails, and this practice somewhat lightens the work of moving the ring rails upwards, and tends to diminish wear and tear of some of the parts.

The Formation of the Cones on the Cops or Bobbins.

While there is a good deal of resemblance in the underlying principles by means of which the cones are formed on the cops from ring-frames and mules, yet the mechanism used for the purpose is much simpler on a ring-frame than on the mule. To begin with, it is usual to lengthen the cop chase out to a maximum on the mule when obtaining the full diameter of cop, and then afterwards to shorten the chase or top cone in order to get more yarn on each cop. It is not usual to attempt any such thing on the ring-frame, but to allow the top cone to remain at one length after it has once attained its maximum. A common method of obtaining the cones may be described as below. Upon one of the chain blocks at the end of the frame is fitted an adjustable finger or snug which is brought well into action at the beginning of each set of cops, so that it bulges the chain outwards and prevents the ring rails from dropping down as low as they would otherwise do. In this way the chase or traverse of ring rail is diminished in length in the earlier stages of cop building. The operation of the shaper wheel gradually causes some of the first copping chain to be wound out of action or this chain to be shortened, so that the cops build farther and farther up the spindles until ready for doffing. At the same time, however, the coning block or bulge piece is moved more and more out of gear, and for a time partially counteracts the shaper wheel in regard to the lifting of the base point of winding on. In other words, for some little time after doffing the base point of winding is limited in lifting owing to the gradual removing of the coning block, and in this way we obtain a short bottom cone, and a sufficiently long top cone on each cop. The writer has experimented before now by taking the coning block off altogether, with the result that two beautiful cones were obtained, but the bottom cone was practically the same length as the top one. If on a ring-frame it is ever required to make a shorter bottom cone, it is usual to just move the coning block a little more into action, so that it will prevent the ring rail from starting quite as low down as previously, and there is always an adjustment screw by means of which we can start the ring rail at any desired height without affecting the length of bottom cone. So long as we spin upon the ordinary diameter and length of

empty spool there will seldom be much trouble or waste caused by bad noses or bottom cones from a ring-spinning frame.

The Shaper Wheel and its Connection.

There are two details of mechanism directly connected with the chain and bowl arrangement, both details being carried in the end of the long lever of the copping motion. These two details consist of the shaper wheel and the handle arrangement for the return motion when doffing. Take the last named, there is suitably disposed "square" piece to receive the small shaper handle, and when the doffer turns this handle, a pair of bevel wheels rotate the worm wheel shaft and unwind the chain from the bowls. In many cases the bevel wheels are dispensed with, and the square end for the reception of the shaper handle is fixed directly upon the shaper wheel shaft.

The more usual method with the shaper wheel is to have the catch lever come against some portion of the fixed framing at a certain point in the lifter traverse, so that the shaper wheel is moved one tooth for each double traverse of the ring rail.

As in the case of the mule and the flyer frame, a larger builder wheel is put on for finer counts.

Builder Wheel for New Frames.

The present writer evolved a rule for determining the builder wheel in starting a new frame, this being as follows:—

(*a*) Adjust all the levers, chains, pokers, and copping parts to be in correct position for starting the first set of cops.

(*b*) Turn the copping cam round so that the bowl is opposite the thinnest part of the cam, and wind the shaper to its beginning point. Also set the lowest required point on the bobbin. Afterwards move the cam round to have its fullest point acting upon the bowl of the lever, and holding the ring rail to its height limit for the commencement of set.

(*c*) Now turn the shaper until the ring rail has reached its highest position for full bobbins, and carefully count the number of revolutions and teeth made by the shaper wheel in doing this.

(*d*) We may now take a bobbin similar in every way to the one we intend to build, referring to all such features as counts of yarn, length and diameter of cop, diameter of bobbin, and dimensions of cones. Reel the yarn from the cop, so as to determine number of inches.

(*e*) Determine length of yarn wound on bobbin during one complete double lift, or, in other words, during one complete revolution of the cam, a good method being to carefully note exact

revolutions of front roller during this time. From the data now ascertained we may lay down the rule as below :—

$$\frac{\text{Number of double lifts required to build one set of cops.}}{\text{Revolutions of builder wheel}} = \text{Approximate Number of Teeth in Builder wheel.}$$

Doffing and the Doffing Handle.

For the purposes of doffing a ring-frame it is customary to connect a long doffing handle to one of the bowls for the lifter chains. While the frame is normally at work this bowl is locked in position by means of a special stud, and there is a fair length of chain wrapped round the bowl. Assuming we are ready for doffing, the long handle is fitted in position, the locking stud is removed, and then by means of the long handle the ring rail is lowered below its lowest ordinary working position, so as to leave a small portion of yarn on the spindle below the full bobbin, and ready for nipping by the fresh or empty bobbin. Upon the instant the ring rail is lowered to its lowest position the frame is stopped ready for removing the bobbins. After winding the shaper to its initial position by means of the proper small handle, the long handle is turned back again, and the chain wound upon its bowl until the locking stud again locks the motion, and the frame is ready for re-starting.

Another detail of the building motion is the foot lever or treadle, by means of which the ring rails can be raised half-way up the bobbin, so as to ease the yarn for re-starting purposes. For weft yarns it is customary to make rings of very small diameter, and this reduces the amount of strain imposed on the yarn during working. Also there is a much greater distance from the rollers to the spindle points than is usual with warp frames, and this appears to help the yarn to wind and to twist with a minimum of breakage in spite of the reduced amount of twist, and the small diameter of full bobbin. Probably also this tends towards the more equal distribution of the twist and the proportioning of the working strains upon the threads. There may be several cross or rocking shafts in the length of a ring-frame, as used for operating the pokers of the ring rails, and it is usual to link these one to another, and also to those nearest the builder motion by means of thin rods, the chains only being used at the gearing end and for the purpose of passing round certain bowls or pulleys. The rods are cheaper and more rigid than would be a multiplication of the chains.

In some frames the long doffing handle is made to operate through the medium of a quadrant rack which is moved by the

handle and a rack pinion, as if the rack were a lever, carrying also the chain block. Lowering the rack or quadrant also lowers the chain block through a distance of possibly 8 inches or so, and this naturally slackens the chains as required for doffing purposes.

The long lever of the copping motion is now carried by a long and substantial fulcrum stud, and in some cases its out end is confined to a vertical slot with a view of securing the utmost steadiness

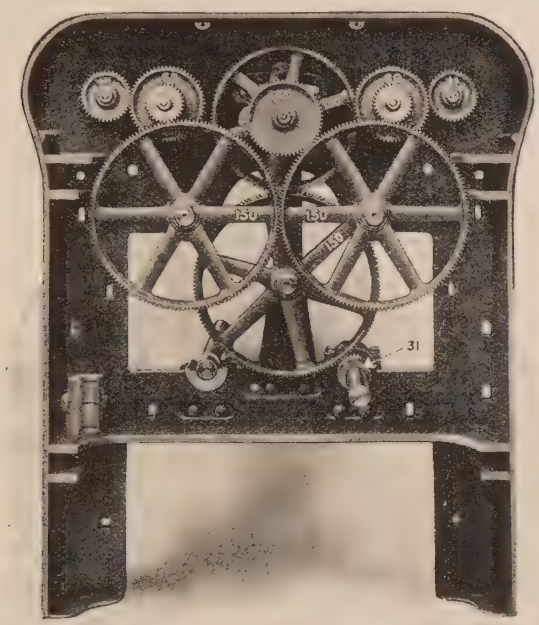


FIG. 96.

Messrs. Tweedale & Smalley show a good long bearing for tin rollers. This gearing plan is otherwise instructive for wheel sizes and driving methods.

in this lever. All such items distinctly help in obtaining well-shaped cops or bobbins. Most people apparently find it best to have a regular time for changing the travellers, and to change an entire frame at one time. The proper regulation of the traveller is, of course, a big thing on a ring-frame. Every care must be taken to prevent mixing of travellers or the use of a wrong size or weight of traveller. Another important point on a ring-frame is the character of empty bobbins. All new bobbins are tested at the

bobbin works before sending away, but it is advisable also for each to be tested at the mill, for "let on" and fit of the base of the bobbin upon the sleeve of the spindle, or in the cup if one be used.

Casablanca System of Drafting.[1]

Several years before the war the author received from abroad samples of yarn spun on the new Casablanca drafting system, which claimed to utilise drafts much higher than any obtained from the ordinary three or four pairs of rollers. References were then made to this system by the author both in lecturing and article writing.

In England, at any rate, not much progress has been made towards mill adoption of this or any rival system differing from the well-established principles of ordinary roller drafting, although recently some discussion has centred around this problem, and reference has been made to systems besides the Casablanca, such as the "Gibelli," the "Cesoni-Lerusse" and the "Vanni." All these are high draft systems, led by the Casablanca.

At the time of writing these notes several ring-frames are being operated upon this system in the Oldham district, with $\frac{2}{2}\frac{3}{5}$ total draft, as against the more usual $\frac{6}{9}$.

Such ring-frame drafting permits the roving-frame to be dispensed with, since a 1·8 intermediate will at the high ring draft give as fine a spun yarn as the normal 5-hank roving with normal drafting. 60 of a draft was suggested originally.

The produced yarn from the high ring draft is claimed to equal the usual one; obviously it should be cheaper to produce.

A greater control of fibres appears possible, but giving more loose fibre about the rollers and beams, and needing more roller cleaning. The principle of work involves using endless leathers below the top rollers. The fibres lie somewhat loosely, and are yet held up very definitely by these travelling leathers, which offer little resistance to the drafting action and rather heavier weighted top rollers.

In the Vanni system, which is somewhat more recent, there are the ordinary three lines of bottomed rollers, and also the back and front top rollers. The middle top roller is dispensed with, and a light leather band substituted which holds the fibres over a wider distance but not very rigidly. (Refer also to Addenda.)

Concentricity of Spindle and Ring.

First Adjustment.—Each spindle requires to be set concentric with its ring, and each thread wire requires also to be set central with the spindle or bobbin top.

To get the spindle top correct with the thread wire, either a

[1] See notes on this in the Miscellaneous Chapter.

plumb may be used from the thread wire or else a hollow circular pointer may be made to don on the spindle, and with its point extending upwards through the thread wire.

The end of the pig tail of the thread wire should point outwards sufficiently to permit the thread to miss the guide with ordinary ballooning. The extended use of metal lappets has reduced the evil of incorrect setting of thread wires and lappets.

Second Adjustment.—In setting each spindle concentric with its individual ring, it is the spindle which is adjusted to the ring and not the ring which is moved. Perhaps it is best for a gauge to fit the spindle in the centre of the lift, but opinions vary somewhat on this point.

Circular, bored, cone gauges are sometimes used for this purpose. The bore fits on the spindle and the cone must fit equally all round against the inside of the ring. One gauge serves for several diameters of ring.

A more favourite gauge is a simple metal ring bored to fit the spindle, and just a clearance only smaller in diameter than the ring it is used for. One gauge for each different diameter of ring.

Sometimes the ready method is used of setting with a good full bobbin.

Any departure from real concentricity of spindles and rings is against good work, and ring jobbers should always have regard to this point.

A source of trouble in this connection is variation at different points of the lifter traverse, especially in long lifts and long bobbins.

The ring rails and all parts of the spindles need to be well constructed, well fitted, and maintained in good condition to ensure concentricity at all times.

Spindles need to be well lined up over the full length of frame, over the full lifter traverse, as well as for each separate spindle if best conditions result. A ring-frame spindle represents the highest type and the most complete development in the spindle line as used in cotton spinning machinery, but its number and character of individual parts are not always conducive to maintaining concentricity over a period of years of hard work.

Perhaps want of concentricity shows up worst when the lifter is in its lowest position.

A final adjustment for concentricity of spindle and ring may be made with the spindle running. Lock-nuts, special tools, and every convenient device should be utilised to prevent spindles from creeping when being finally secured in exact position, or at any later stage.

The importance of this feature has led various repair shops or even individual fitters to specialise in the work and adopt devices not always approved by the machine makers.

To test the settings, it is possible to move individual sectional parts of ring rails up and down as smoothly as possible.

Automatic Lifting of Thread Boards.

On some ring-frames, more especially weft, it has been deemed worth while to apply an arrangement for automatically lifting and lowering the lappets or thread boards along with the lifter or ring rail but to a much less extent—possibly as 1 is to 3.

In this way it is sought to prevent excessive ballooning at the commencement of a new set of bobbins, or when winding on the full diameter of bobbin, and yet possibly using light travellers.

At the same time it is permissible to have high thread boards and therefore more ballooning in top of set, or for small diameters of bobbins.

One method is as follows :—

To some of the cross bars, or lever arms used for lifting the ordinary vertical pokers of the ring rails, are also attached extra snugs or lips much nearer to the fulcrum of cross bar, and upon which are loosely and adjustably placed extra vertical poker bars, which reach upwards to the long hinged bars to which the lappets are separately hinged.

Roving-Frame Bobbin on Ring-Frames.

Occasionally it is desired to build up full ring bobbins of the same shape as roving-frame bobbins, with double equal cones and a straight up and down lifter traverse every time, but the traverse slightly and gradually shortened at both ends to produce the equal cones. Also to give a very close wind and a uniform pitch of coils all the time.

In this way a maximum length of yarn can be got on each bobbin, and the roving-frame build gives side unwinding from revolving bobbins. Hard twisted or crepe yarns furnish an example of sometimes wanting side unwinding. This kind of bobbin also only permits the outside or top layers of yarn to get dirty, if kept long in stock, excepting at the cone ends.

The long lever of the copping motion is operated in much the usual manner by a cam driven from one of the upper gearing carriers and an inclined shaft.

1. The cam for moving the long lever is of the heart shape in order to give an equal up and down traverse.

2. Two different worm and worm-wheel gears are compounded with a double purchase gear having two large driven wheels in order to give a very slow rotation to the cam and thus obtain very close coils.

3. This cam is of large size and good throw, and placed slightly nearer to the fulcrum of long copping lever, in order to obtain a long parallel lift and bobbin wind.

4. A special shortening device is applied in order to produce the double bobbin cone by gradually and equally shortening the lift.

In one arrangement a segmental rack is geared with a worm fixed on one end of a short spindle on the outer end of which is secured a shaper or builder wheel. The rack, the worm, and the shaper wheel are all carried up and down with the out end of copping lever. The link rods and chains of the lifter are coupled to the segmental rack. This connection is held at its outermost point in the long lever for fresh bobbins, but the shaper wheel is gradually moved so that the worm gradually takes the link point nearer and nearer to the long lever fulcrum, thus gradually shortening the throw of the whole lifter connection to the long lever.

CHAPTER VIII.

MULE SPINNING.

Amount of Carriage Gain. Egyptian and Sea Islands Cotton.

It is an axiom in cotton spinning that the finer the counts of yarn being spun the greater will be the permissible amount of gain, although much of this effect is due often to the better quality of cotton used for the finer counts. However, coarse yarns will tighten more rapidly than fine yarns under the influence of twist, and will resist drag or gain, and this effect is increased by the general practice of putting all the twist into coarse yarns as the carriage moves out without using any twisting at the head. It is frequently the case that about 30's twist yarn, or lower, is spun from American cotton without any gain of carriage at all, and still lower counts may even deliver more from the rollers per stretch than the carriage will travel. (*a*) Coming now to the quality of cotton, it is an undoubted fact that more gain can be put into a better, finer, and longer fibred cotton than into a poorer cotton, all other circumstances being equal. This feature is greatly accentuated by the general use of twisting motions and low spindle speeds and keeping the twist per inch low as the carriage moves out, when spinning the finer and better qualities of yarns from good cottons. Good cotton will hold together, and will spin well with low twist, thus often enabling several inches of gain per stretch to be put in for fine counts as compared with little or no gain in coarse yarns from poor cotton. (*b*) As stated, a low spindle speed relative to carriage really means keeping the yarn soft owing to small amount of twist put in, and this condition greatly favours the use of a good proportion of carriage gain and is the chief reason for the extensive use of twisting motions for any yarns. If a mule spinning a medium count carded Egyptian yarn were changed to a Sea Islands quality with same counts twists and gain the relative speeds of carriage and spindles might remain the same because the drawing-out, and gain wheels and rim pulley have not been altered, unless, indeed, we put more twist in coming out and reduced the supplementary twist proportionately, so as to get more production from the better cotton. The better cotton ought to permit really of a

larger rim pulley and increased production, so long as the twist was kept the same as per question. Wider set rollers, increased spindle bevel, increased carriage gain and second stretch, reduced twist, lower spindle speeds, lower twist multipliers, are the more usual accompaniments when using Sea Islands cotton.

Segmental Tuber for Long Tubes.

This pattern of tuber is designed more particularly for placing long tubes to reach all through the cop. It is also applicable, if

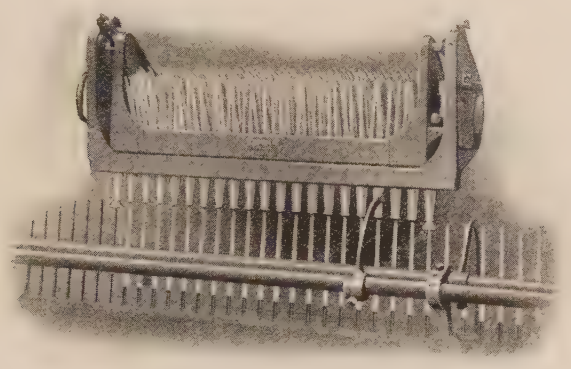


Fig. 97.—Tuber for long tubes.

required, to all lengths of shorter tubes with the same tuber. The tubes are dropped into the holes in the carrier and held in upright position.

Jagger's Tube Setter.

This tube setter is for the purpose of pressing the tubes down to the distance required after being dropped upon the spindles by the apparatus. It consists of an aluminium plate, with notches spaced to guage of spindles, and adjusted by two stop-screws and their lock-nuts.

Fig. 98.—Tube setter.

The stops come in contact with the spindle rail, and thereby set the tubes all of equal distance therefrom.

Where spindle rings are used the stops are not necessary.

To Change from Twist Cops 25's to Pin Cops 36's.

Builder wheel now on . . .	30
Gain wheel	90
Drawing-out wheel	60
Draft change wheel	54
Diameter of rim pulley . . .	15 inches.
Diameter of twist cop . . .	$1\frac{1}{4}$ „
Diameter of weft cop . . .	$\frac{7}{8}$ „

Problem I.—The Change Wheel.

1. *Builder Wheel Rule.*—Obtain the new wheel by square root, and also by simple proportion. Add these two answers and divide by 2. This determines wheel to suit alteration in counts. Then find the wheel as affected by the difference in diameter of cop.

(*a*)
$$\sqrt{25} : \sqrt{36} :: 30 : ?$$
$$= 5 : 6 :: 30 : ?$$
$$\frac{30 \times 6}{5} = 36.$$

(*b*)
$$25 : 36 :: 30 = 43{\cdot}2.$$

(*c*)
$$\begin{array}{r} 36{\cdot}0 \\ 43{\cdot}2 \\ \hline 2)\overline{79{\cdot}2} \\ \underline{93{\cdot}6} \end{array}$$ say either a 39 or 40 builder wheel.

The softer yarn may need so much less weight on the fallers that the smaller builder wheel may be needed to counteract this. Assume the 39 now to account for the difference in diameter of cop.

(*d*) Areas of cylinders vary with the squares of their diameters

$$1\tfrac{1}{4} \text{ inch} = \frac{20}{16} \text{ and } \tfrac{7}{8} \text{ inch} = \frac{14}{16} \text{ inch.}$$

$$\therefore \quad 20^2 : 14^2 :: 39 : ?$$

$$\therefore \quad 400 : 196 :: 39 : ?$$

and
$$\frac{196 \times 39}{400} = 19\text{'s builder wheel to be applied.}$$

Such points as amount of faller weight, twist per inch, shape of cop, and distance of winding faller wire from spindles during winding may affect exact size.

2. *The Draft Change Pinion.*—We have on 54 for 25's, find wheel for 36's.

$$\frac{25 \times 54}{36} = 37{\cdot}5 \text{ draft pinion.}$$

Again, this must be checked according to the influence on counts of yarn of such factors as, increased gain of carriage, increased twist per inch, reduced weight on fallers. Either 38 or 37 may be applied at first.

3. *The Drag or Gain Wheel.*—This does not lend itself very well to a calculation, and depends more upon judgment, effect of increased twist, reduced carriage speed and actual experience.

As a test change the 90 for an 89 to get about $\frac{3}{4}$ inch more drag in the stretch, and then judge by results. If 90 wheel delivers 64 inches, what will 89 deliver? A shorter length.

4. *The Drawing-out Wheel.*—(*a*) Increase as $\sqrt{25}$: $\sqrt{36}$ for counts in order to get the requisite increased twist per inch by reduced speed of carriage and rollers.

$$\sqrt{25} : \sqrt{36} :: 60 : ?$$
$$= 5 : \quad 6 :: 60 : ?$$

$$\frac{60 \times 6}{5} = 72 \text{ drawing-out wheel.}$$

(*b*) It might be better in a particular case to obtain some of the increased twist by increasing diameter of rim pulley, in which case the drawing-out wheel would be proportionately reduced in size.

Assume a 16 inches to be applied instead of the 15 inches speed wheel.

Then 16 : 15 :: 72 : 67½ say put on either 67 or 68.

In fine counts we should need also to consider the twist wheel, as well as the speed wheel.

We have now a further refinement to allow for in that the twist constant for pin cop weft is $3\frac{1}{4}$ whereas for twist yarn it is $3\frac{3}{4}$.

Adhering to the standards for American cotton this means the statement below, assuming that we take 67½ as given previously,

$$3{\cdot}75 : 3{\cdot}25 :: 67{\cdot}5 ?$$
$$\frac{3{\cdot}25 \times 67{\cdot}5}{3{\cdot}75} = \underline{\underline{58{\cdot}5}} \text{ speed wheel.}$$

Problem 2. *Copping Alterations: Twist Cops to Pin Cops.*

1. Shorten the top cone or chase of cop by means of the vertical screw of the copping rail, noting that $\frac{1}{8}$ inch on the screw usually equals $\frac{1}{4}$ inch on the faller wire.

2. Shorten the boot leg or locking lever so as to start the first draw with the winding wire much higher up the spindles—say about $1\frac{1}{2}$ inch or so. Note that $\frac{1}{8}$ inch on boot leg equals $\frac{1}{4}$ inch on faller wire.

3. Re-set the stop-screw for determining how far you wind the shaper up at doffing time, so that you use about $\frac{1}{2}$ inch or so less of both back and front copping plates, but put back plate about $\frac{1}{4}$ inch forward again to prevent cop bottom being too long first few draws. Using less of the plates shortens the cones of the cop to agree with the smaller diameters.

In some cases there are twist and weft starting marks on the copping plates.

4. Start the quadrant nut lower down the radial arm if possible, to get the threads winding tighter in order to compensate for starting the cop bottom higher up the spindle.

In some cases a smaller diameter of winding drum or a larger size of winding drum wheel is used for the pin cops. Another method is to use metal or other clips for the winding drum for the larger diameter of cop and remove the clips for the pin cops.

The clips may be in two halves and set-screwed to the winding drum.

The clips have also been applied in some cases when changing to very coarse counts and spinning on every other spindle to get a very large diameter of cop.

In some cases the quadrant has been set farther back or a different quadrant pinion applied.

5. For twist copping rails the first fall $4\frac{1}{2}$ inches from the ridge may be $\frac{1}{16}$ inch and the final fall $\frac{1}{4}$ inch, while a weft rail may take little more than half these falls, and there are cases in which weft rails are put in for the pin cops, especially if the change be for a good length of time. More often the twist rails are made to do for the pin cop, and blunting the cop nose by locking more shallow, or still further shortening the cop chase or starting quadrant farther back.

Problem 3. *The Faller Wire and the Sector. Twist Cops to Pin-Cops.*

The sector is the name given to the half-round finger or arm which connects the locker lever to the copping faller shaft.

Because the base point of winding on the spindle is usually considerably lifted in spinning pin cops on twist spindles, the relation of the winding wire to the sector and faller shafts is disturbed.

For one thing there will be a tendency to build rather softer

cops in the early stages and to produce run under threads, owing to the winding faller wire being too far away from the spindles for some time after doffing.

For the best results, the two faller shafts should be lifted a little higher and farther back from the spindle points for pin cops than for the long cops, in order to get the winding wire at or near the centre of that portion of the spindle blade on which the cop is built, when the sector stud is in same horizontal centre as the winding faller shaft.

Altering the sector adjustment is somewhat troublesome—especially on some mules—and altering the height of the faller shafts is considerable trouble. For this reason they are not touched in many cases when changing from large to small cops, and often quite passable results are obtained by using rather longer top and bottom cones, increased faller weight for the pin cops, and possibly deeper locking, than would be used with a correct sector and copping rail, and distance.

If it is desired to correct the height of faller shafts use a faller shaft gauge as elsewhere explained herein.

To adjust the winding wire better in relation to the sector we may lift all the winding wires about $\frac{7}{8}$ inch from end to end of mule by means of the sickles. Then unlock the fallers and reset the faller hammers, springs, governing motion, backing-off, etc. Finally set the wire to start at correct position down the spindle.

Spinners and overlookers accustomed only to spinning twist or large cops should remember the following points when required to spin pin cops :—

1. Cops made too long cannot be got on the shuttle tongue, without pulling some yarn to waste, and so accurate measuring of cop lengths, or automatic doffing stop-motions are even more important for pin cops than for twist.

2. On the other hand, frequent shuttling of fresh pin cops is often a great trouble to a weaver, and the cops should be made as large as the shuttle will properly take.

3. If pin cops are too thick they will not go in the shuttle, and if too thin they are finished too soon.

4. If cop tubes are too small in the aperture they will not shuttle properly, and if too large in the aperture they will knock off in the loom.

5. The Northrop automatic loom has been adopted in many mills. It automatically forces an almost empty weft bobbin out of the shuttle, replaces a full one, and properly threads the weft in the shuttle. If a warp thread breaks the loom is automatically stopped. A weft magazine will hold from seventeen to twenty-five cops, which can be put in the magazine while the loom is working.

Round v. *Vertical Guide Apertures for Rovings and Slivers.*

In considering the guide apertures it may be as well to point out that in several machines used in cotton spinning it is a question whether it is better to use round apertures or vertical spaces for the guidance of the cotton to the rollers; the sliver lap machine, the draw-frame, the several bobbin and fly-frames, the mule and the ring-frame being the chief machines in which this point arises. In a mule, for example, which is only intended to be used for single roving it appears to be most preferable to use back tins in which there is one vertical slit for each roving, the slits being deep enough to serve for top, middle, and bottom rows of bobbins. These afford the greatest facility to the piecer or spinner for piecing broken bobbins, and do not appear to collect bad ends any worse than other kinds of guides.

The position, however, is altered when we come to use double roving with front top rollers as narrow on the boss as can be reasonably obtained. For fine twist this boss is often only $\frac{3}{4}$-inch wide, and for pin cops as low as $\frac{5}{8}$ inch is often used, so that the rovings need to be held in a very definite path, or running off at the roller ends will soon become a great trouble. Moreover, in such cases it is the common practice to use double rovings, and it is very inadvisable to have a pair of rovings much separated from each other in passing through the rollers. For these reasons it is the more common practice on fine-spinning mules to use small round apertures in the back guide tins—such as are very often used for the same purpose on roving and intermediate frames.

For single roving the small round apertures would be very troublesome when piecing broken bobbins—much more so than the vertical slits open at the top. With double roving, however, it is comparatively seldom that both the rovings of a pair are broken together, and it is usually easy to piece one to the other, taking care to have the front thread broken to prevent a bad end or piece of single. There are some practical men, however, who prefer a modification of the vertical slit for double roving, and accordingly some fine mules have vertical guide wires made of about 13's wire suitably bent, and which will hold the rovings in a narrow pathway, while permitting a kind of hooking in of broken rovings without absolute threading through. The small round apertures, however, are most in favour, being practically indestructible, easily cleaned, and affording the minimum opportunities for collection of fibre.

Middle Guide Tins.

Whether the small round apertures are used, or the bent wire ones for double roving on the fine mules, it has been found expedient

to also use plain middle guide tins without slots or apertures, but which definitely keep the rovings intended for one spun thread a certain distance from those for the other thread on the same roller. The pitch of these tins is slightly greater than that of the small round apertures in the principal guide tin, and this slight difference of pitch helps to keep the rovings always in the exact position required, and diminishes loss in traverse action at the change. The middle tins are connected to the back ones, and partake, therefore, of the same roller traverse motion. In spite of the slight tendency for bad ends to form on these middle tins this evil is less than the alternative one of permitting the pairs of rovings to spread about somewhat in passing through the draft rollers.

Notes on Mule Gauges and Settings.

Re-setting may be divided into three chief sections:—

1. All belonging to the headstock.
2. ,, ,, ,, roller beam and creels.
3. ,, ,, ,, the carriage, fallers, and spindles.

In setting headstock parts it is required to have the rim shaft parallel with the counter shaft and the live shaft.

The spirit level helps in setting the various chief shafts of the headstock, such as the rim shaft, side shaft for taking-in, front roller spindle cam shaft, short drawing-up shaft, and tin roller shaft. Every one of these shafts must revolve with absolute freedom in its bearings.

Lining-up strings from end to end, roller gauges, and spirit level are valuable in getting the rollers correct.

Several gauges are used in a thorough repair and re-setting of a self-acting mule.

Topping.

In Sheet 1, Figs. 1 and 2 represent "topping gauges," Fig. 1 using the spirit level and Fig. 2 using the plim-bob. Either method will give good results if properly used. In each case A_I, A_{II}, A_{III} are the rollers. By "topping" is meant the distance of spindle points below and away from the front roller when the mule carriage is stopped against the back stops.

For about	28's	to	40's	the spindle points may be	$2\frac{1}{8}''$	down	×	$2\frac{1}{2}''$	away.		
,,	,,	80's	,,	100's	,,	,,	,,	,,	,,	$3''$	,,	×	$2\frac{3}{4}''$	,,
,,	,,			200's	,,	,,	,,	,,	,,	$3\frac{1}{2}''$	,,	×	$3''$	,,

The gauge is made level by the thumbscrew C, and then readings are taken on the gauge to the spindle point at E or F.

The topping is altered by the vertical rising screws in Fig. 7.

Spindle Bevel.—Gauges 5 and 6 are examples of gauges which

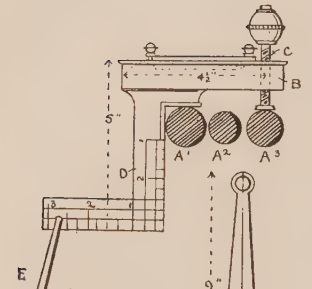


FIG. 1

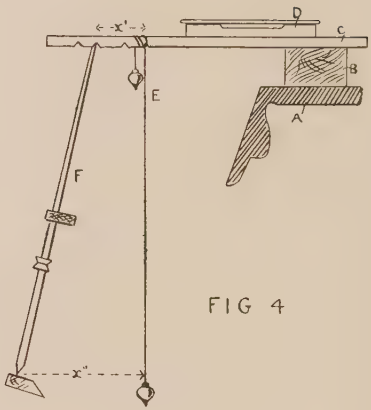


FIG 4

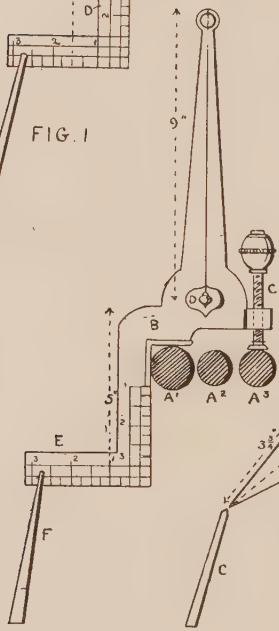


FIG 2

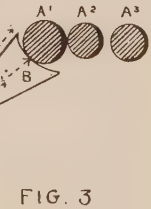


FIG. 3

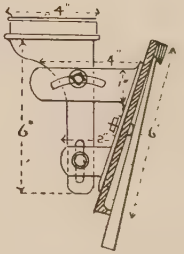


FIG 6

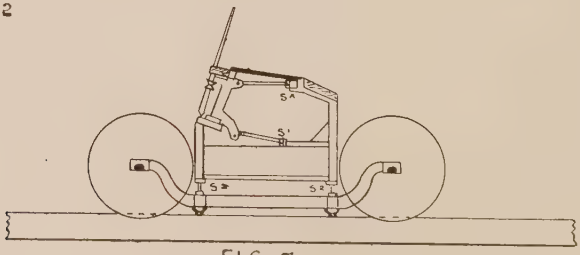


FIG. 7

Fig. 99.—Mule gauges. Sheet 1.

may be used when setting bevel. Fig. 5 uses the plim-bob and Fig. 6 the spirit level and either gauge will serve the purpose if properly

made and used. Bevel is usually altered and adjusted by the top and bottom stay rods S′, S″ in Fig. 7. By means of some such arrangement as shown in Fig. 4, a few spindles may be first adjusted to requirements, or the level at any time tested. (See sheets 1 and 2.)

In Fig. 4, A is the roller beam, D is a spirit level placed on a parallel straight edge C. B is a wood packing, placed on the roller beam A. The distance from spindle point to plumb line may be subtracted from the distance of spindle foot to plumb, in order to determine the bevel. The gauge is adjusted to these first corrected spindles and then all other spindles set to the gauge. Strict attention must be given to the question of whether it is better to adjust by the top or the bottom rod, in order to keep the spindle points correct with an extended string line, and the rails sitting properly on the carriage. Quick alterations in bevel are sometimes made by the vertical carriage rising screws, or even by changing for a different size of carriage wheel, but may upset other settings if not done with good judgment.

For counts 28's to 46's or so a good general rule for bevel is to put in $\frac{1}{4}$-inch bevel for every inch of spindle length so that a $17\frac{1}{2}$-inch spindle would have $4\frac{3}{8}$-inch bevel as used for ordinary twist or warp yarns. Any yarns that are weaker usually require somewhat increased bevel, so that wefts have more bevel than twist yarns, for equal lengths of spindle, and fine yarns more than coarse yarns. Too much bevel gives snarls and allows yarn drawing off during spinning. Too little bevel pulls the threads down.

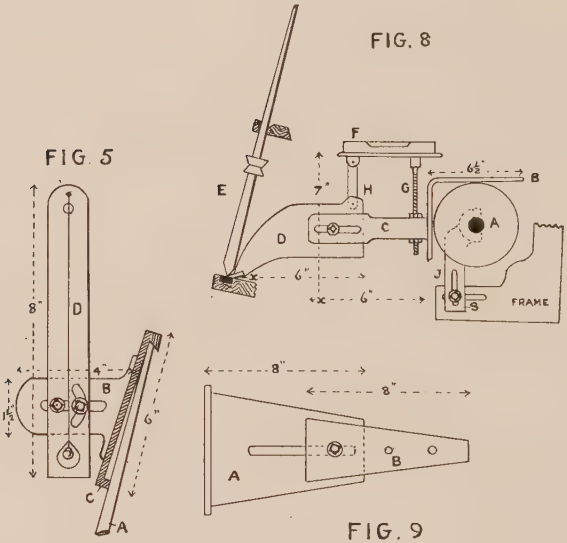
Faller Shafts.

The faller shafts require to be a definite distance below and in front of the spindle points, in order to maintain the faller wires in a definite and true position for backing off and winding on. Also to have the sector in true working position. In sheet 2 Fig. 10 shows two views of a convenient faller shaft gauge.

Piece A is properly grooved to hang upon four or five spindles at A. A slotted finger C projects over the top of the faller shafts and gauge slots are provided to get proper settings.

In setting, the faller shafts are moved about at each stand until there is a clearance between D and winding faller shaft E both in front and on top of E.

First of all a stand or two at the headstock may be put right by experiment and measurement. The setting of the sector being closely noted at the same time. Platts make a faller finger which requires setting about horizontal for sector purposes. In other cases, a 2-diameter finger may be put in the position of sector stud, a spirit level be extended across from stud to winding faller shaft,



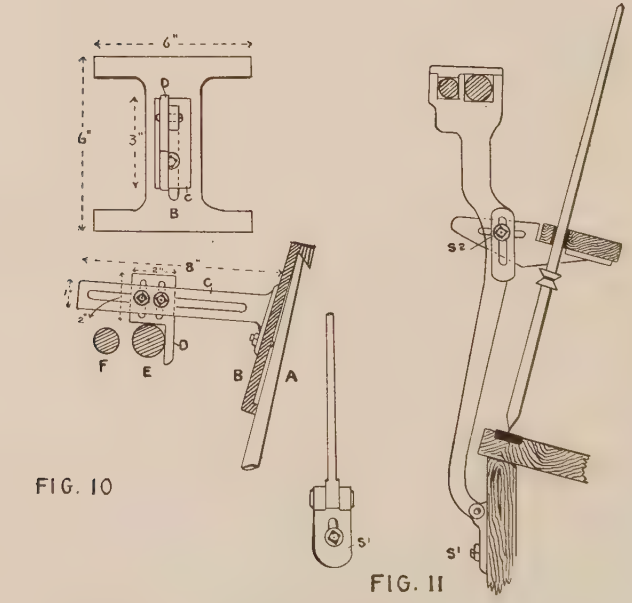


Fig. 100. Sheet 2.

and the faller wire be put in centre of its full winding position top to bottom of cop, while the faller stands are then screwed firm.

Fig. 11 shows the two setting points for the faller stand. E, F represent faller shafts in Fig. 10. (See sheet 2.)

Tin Rollers and Spindle Wharves.

The tin rollers require to be adjusted for (*a*) distance from spindles; (*b*) level on the top; (*c*) correct height in relation to the spindle wharves so that the bands shall pull at the correct angle on the wharves; (*d*) to be in a straight line, resting properly on the bearings, and turning freely in the bearings.

Self-adjusting, ring bearings help to maintain correct working, and experiments are being made in ball bearings for the tin rollers. Metal carriages, and lighter ends to the tin rollers are among other developments touching this matter.

If the spindle bands pull too much up at the wharves the spindles may jump or dance, while bands pulling too much down cause heavy running of spindles. As a basis, it is taken that a rule extending from the bottom of the wharve inside the carriage, should pass below the centre of tin roller shaft.

For 17″ spindle the straight edge may pass $\frac{9}{16}$″ beneath tin roller shaft.
16″ ,, ,, ,, ,, ,, ,, $\frac{3}{8}$″ ,, ,, ,, ,,
15″ ,, ,, ,, ,, ,, ,, $\frac{3}{16}$″ ,, ,, ,, ,,
14″ ,, ,, ,, ,, may touch underneath shaft.

A fine spinning firm using 6 inches bevel for a 16½-inch spindle set from top of wharve to centre of shaft.

A simple tin roller gauge is indicated in Fig. 9 for giving distance only, the broad end touching the spindles, and narrow end the tin rollers.

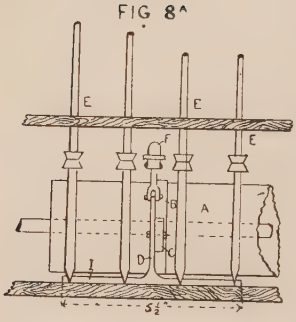
A much more ambitious gauge, as used by the author as far back as 1892, is shown in Figs. 8 and 8*a*. (Sheets 2 and 3.)

It indicates both distance and level. A is the tin roller, which should be just a clearance from the finger C.

Finger B may rest on top of tin roller, and the tin roller adjusted to have the spirit level F reading correctly. Piece D fits against four or five spindles.

Cop Gauge.—Fig. 15 shows one of many forms of cop gauge, and is more likely to be wanted for weft cops than for twist. Of any hard material such as strong tin, hard wood, or brass. There are some gauges also shaped out to the cones of the cops as to lengths and shapes of these.

Faller Sickles.—The sickles are weak and pliable and sometimes get bent so as to hold the faller wires too close or too far away in relation to spindle points in backing-off. Fig. 12 shows a handy



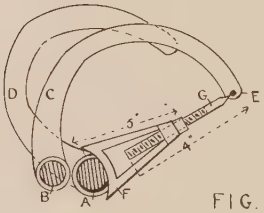
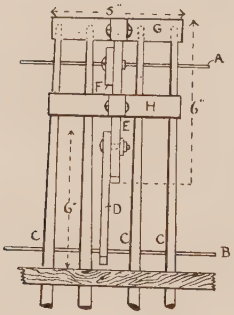


FIG. 12



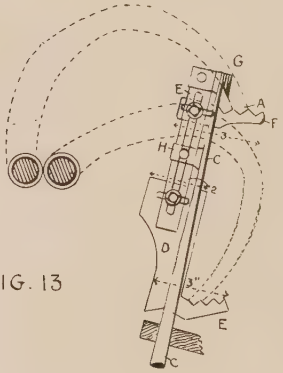


FIG. 13

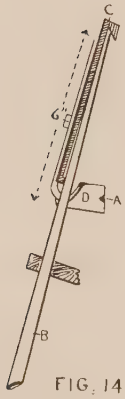
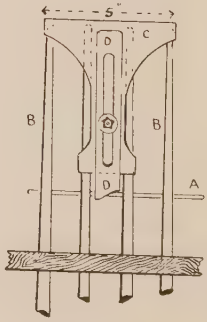


FIG. 14



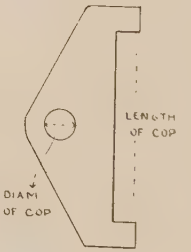


FIG. 15

FIG. 101. Sheet 3.

guage of brass or other metal for quickly judging the sickles. At A is the winding faller shaft with its sickle B, while *a*, *b*, represent the counter faller shaft and its sickle. F, G shows the gauge in position.

The Faller Wires.—There is a distinct tendency for faller wires to become crooked, irregular, or out of truth due to such things as faller wires breaking and being pieced or renewed, faller wires getting fast, sickles bent or other things being altered.

Fig. 14 shows a simple faller wire gauge for the winding wire.

A is the faller wire resting in a slit in the finger D which projects through the spindles B and is vertically adjustable.

C hangs on four or five spindles and against them. Marks or hollow portions can be arranged in the finger D for the wires to fit in.

Setting of faller wires from the bolster is liable to give inaccurate results, and it is safer to set wires from the spindle points as shown.

It is not a big job re-setting the wires, and often it produces much better results in winding, cop shaping, and getting all cops equidistant from bolsters at bottom of cop, and spindle points at top of cop. A pipe gauge may be used, having the spindle fitting inside it.

Fig. 13 represents a more elaborate gauge for setting faller wires, there being a setting finger for each wire. The counter wire rests on finger F, while winding wire rests on lower finger D, E rests on four or five spindle points, while H rests against the front.

Gauge for Testing the Working Foot of the Boot Leg.

It is considered that the boot leg or locking lever of a self-acting mule should be capable of moving backwards and forwards (when locked) without causing the winding faller wire either to depress or to lift. Any such movement of faller wire would tend to affect the copping, and also the tension of the threads at unlocking time.

Briefly, most people agree that the foot of the locking lever should be concentric with the centre of the stud on which it swings A simple gauge is intended to help in finding the truth or otherwise of this feature, and to give the true curve.

A long screwed rod has on its upper end a screwed extension piece containing the round hole to swing on a stud on locking lever fulcrum. For using, the ordinary stud of the locking lever may be substituted for a longer one which will also allow the swing piece to be hung therefrom at the top aperture. The bottom pointer is fitted as near as required to the locking lever foot, and will either give the test or make a mark on a chalked portion to show the curve required.

Mixing Long and Short Fibres, also Cottons of Different Colours.

It is not quite true to state that under no circumstances whatever can long and short fibres or brown and white cotton fibres be mixed together to advantage, although it is true in general.

When Joanovitch Egyptian invaded the fine spinning trade about 1900-3 it was refused by many spinners because of its lighter colour than the brown Egyptian. A few alert spinners, however, were greatly impressed by the length, strength, and—at first—moderate price, and soon found a method of stopping stripiness in the yarn.

The remedy was to run the differently coloured cottons separately up to the draw-frame and then to mix and put up together slivers of the different cottons in the proportions desired.

Uniformity of colour was thus very definitely obtained, although the finished yarn had a lighter appearance than the full brown effect.

In March, 1922, some "outsider cottons" of good quality were cheaper than some standard cottons of shorter staple. Example: Peruvian cotton, $1\frac{1}{2}$ inch in fibre length, was 1d. per lb. or more cheaper than the best standard $1\frac{1}{8}$ inch Texas; spinners mostly were afraid of using the longer fibre, but a few very successfully adopted the following method. Mix the Texas and Peruvian at the draw-frame. Spin the yarn on the mule, using self-weighted middle top rollers, and set inside the fibre length front to middle rollers. A fair amount of carriage gain to keep crackers from forming by short fibres twisting round long ones.

Slub Yarn Motion.

A slub yarn motion as applied successfully to a number of self-acting mules, inspected by the author, may be briefly described as follows:—

The front roller pinion drives the large crown wheel of the draft train of wheels in the usual manner, and the crown wheel is fastened to an extended spindle, and is hollowed out on its inside to carry four small catches near the rim and having their catch points coming down upon a very fine tooth mild steel ratchet wheel fast on a bush or sleeve. This ratchet wheel, a second one near to it, a lever and catch for operating the second ratchet wheel, and the change pinion for draft, are all four carried upon a sleeve or bush running loose on the extended spindle of the crown wheel. The change pinion drives the back roller wheel in the usual manner and is of size required to give the proper draft. A chain is connected to the middle ratchet wheel lever, and extends downwards to be acted upon by the carriage every time the latter reaches the beam.

Ordinarily, as the carriage moves out the draft is normal, and one or other of the four crown wheel catches is sure to be in prompt and correct gear to drive the change pinion, back roller wheel, back and middle rollers, the middle rack wheel now running away from its catch. As the carriage in its inward run nears the back stops, the chain is taken along and moves the middle catch-lever so as to give the back and middle rollers as much extra movement as wanted for the size of slub. The first catch wheel now races away from the crown wheel catches in the approved free wheel fashion. A prompt return is wanted for the catch lever, either by spring, or weighted rope or chain.

If the cotton is too long in fibre or too well twisted, slubs will often be produced too long, as the rollers may fail to take up the drafting action again promptly and effectively.

A soft twisted 5-hank Egyptian would slub better than double roving 10-hank. It has been the author's experience that mule slubbing motions have often given trouble by this failure to give the correct slub on every spindle, every time. The motion above explained gives only one slub in the length of stretch.

There are other slubbing motions worked from the back shaft which give two, three, or more slubs per stretch length of yarn, but these also have sometimes given trouble in regard to correct slubbing action.

Mules: Long v. *Short Shaper.*

The long shaper rail has its actual working profile always rather longer than the full length of stretch, so that there is a small portion left unused at both extremities, besides the long supporting portion at the extreme front. For a 64-inch stretch twist mules the loose front incline may be possibly 15 or 16 inches or so in length, and the long incline possibly 51 inches or so. The short shaper is almost confined in use to mules spinning the finer numbers of yarns, but many mules spin fine counts with the long rail. The short shaper rail may have a front incline of possibly 4 or 5 inches in length and a long incline of possibly 12 inches or so. This short rail of possibly 16 or 17 inches over all the working portion is made to serve for a stretch up to 64 inches or so by being taken forward with the carriage at a slower speed, so that the carriage and locking lever gain on the copping rail for the 16 inches or so required. There is a long rack fastened to the floor underneath the headstock and a shorter one coupled to the framing which carries the copping rail. The two racks are coupled together by a double wheel or Montgomery wheel, the smallest size of which, say eleven teeth, gears with the short movable rack, while the larger wheel of, say, thirty-nine teeth, gears with the fixed long

rack. The short shaper is more likely to be displaced from its position in quick running mules and is seldom used for them. This defect does not show up much in slowly running fine mules, and it can be altered better to varying lengths of stretch or to have a greater or less amount of shaper to be used.

Fine v. *Coarse Mule.*

The chief differences between a mule for spinning 100's and 32's twist and weft.

The chief differences consist in the fine mule containing several motions either extra over what the 32's mule has or else somewhat different as below specified :—

1. During the last short portion of the outward run of carriage from $\frac{1}{4}$ inch up to 4 inches or so the rollers of the fine mule may stop either entirely or almost so, whilst the carriage finishes its traverse at only about one-fifth its spinning speed. This is termed putting ratch or jacking into the yarn.

2. The receding motion controls the delivery of a small amount of yarn during jacking and supplementary twisting.

3. Practically all mules spinning 100's would be supplied with a winding roller delivery motion, but only comparatively few of those spinning 32's.

4. Many modern mules for spinning 100's or finer are now equipped with the "fine rim motion" or "snicking motion," for giving an extra spindle speed during the last short portion of the run in.

5. Some few fine mules are fitted with faller lifting motions.

6. Supplementary twisting is usual for 100's twist and often for 100's weft, but is hardly ever used for 32's twist or weft from American cotton.

7. Double speed motions are often used for 100's twist, and occasionally for 100's weft, to give an extra spindle speed during head twisting.

8. Single thread boss rollers, increased spindle bevel, fallers working in anti-friction bowls, belt taking-in, finer-pointed spindles, double roving, special traverse guides, short copping rails, self-weighted back and middle top rollers, four heights of creel and backing-off by cam, are all extensively used for fine spinning mules, but not for 32's American cotton.

Defects in Yarns.

The nature and appearance of the various defects in single yarns which may be developed by the faulty action or setting of each of the following organs of the mule or ring-frame : (*a*) bottom

fluted rollers, (*b*) top draft rollers, (*c*) spindles, spindle bands, and tin rollers.

(*a*) Bottom fluted rollers sometimes become damaged, and will then often break adjacent threads, and cause bad ends. It is possible for the flutes to be badly worn, so as to give imperfect drafting, or on the other hand to be so sharp as to tend to cut the yarn, but these defects are comparatively rare. Setting the centres of front and middle rollers too far apart may give uneven drafting, or setting too near may lead to "spewing" of the cotton in raw undrafted portions, especially with lever weighting of top rollers.

(*b*) Channelled top rollers inevitably break the yarn while fluted top rollers give uneven drafting, but both evils are self-evident, and the remedy in each case is obvious. Rough places on the leathers will cause excessive breakage of threads, and also give bad ends, and the rollers should be examined when such evils occur. If the top rollers are dirty, insufficiently lubricated, not set parallel with the bottom ones, or the weights and saddle are not properly applied, the yarn will be thicker and harder, and will break excessively. Examination of the rollers will readily discover the particular cause.

(*c*) Slack spindle bands is a common fault, and leads to soft cops and weak, insufficiently twisted yarn, but a mule or ring-frame worker can easily detect the evil and provide the remedy with a new band. If the spindles vibrate excessively it tends to weaken the yarn, and the cause is very manifest.

Sometimes tin rollers are out of the true or improperly adjusted, and this will tend to weaken the yarn by giving vibration to the working parts of the frame. Occasionally it happens that a tin roller has become a little loose, and this may manifest itself in softer cops and weaker yarn due to the slippage. Generally speaking, the number of cops thus affected will enable a practical man to trace the cause. Stained yarn is sometimes caused by careless and excessive oiling of top or bottom rollers, and a glance at such yarn indicates the probable cause. If the spindle points vary in thickness some threads will be slacker than others, and careful examination is needed to detect this defect in spindles.

Bad ends are often caused by bobbins over-running, or by fly accumulating on rollers and then passing into the yarn.

Crow Laps and Fluker Rod Waste.

The under clearer waste from a mule or ring-frame is of a choppy detached character, due to the fact that the waste from one separate end of cotton is often so to speak in a small roll to itself. There is so little sand left in the cotton that issues from the front rollers of mules or ring-frames that really the waste is bound to be

clean. Moreover, this waste is very largely composed of good long fibres because it is more due to broken ends running in the clearer than it is to waste being rubbed off the bottom roller.

From the point of view of being used over again it is probable that the greatest defect of under clearer waste from mules and rings is the presence of a good deal of twisted thread, which winds round the softer waste, and afterwards requires a great deal of extraction. As stated elsewhere, thread extracting machines are now on the market for the special treatment of this clearer waste from mules and rings, so as to get the twisted threads out in the most effective manner possible, and with the least injury to the fibre.

In mules of coarse numbers, or any mules with weight hooks passing down between front and middle rollers, it is usual to employ short flannel covered "crows" or "sticks" as under clearers. Also, in fine spinning mules this practice is sometimes adopted in Oldham and other districts where the spinners are not accustomed to the fluker rod system. The latter consist of iron rods which do not actually touch the bottom rollers, and each rod extends the length of a half-mule, and is set a little farther under the front roller than the "crow." This system suits the short rollers and front weight hooks universally adopted in the Bolton district, and some other centres of fine spinning.

Top clearer waste from mules and ring-frames presents scarcely so bright an appearance as a rule when compared with under clearer waste, as it more often largely consists of bits of fibre rubbed off the leathers.

The top clearer waste of long top clearers used for fine counts, with self-weighted middle top rollers, is often termed "stockings," from its long full hollow appearance as drawn over the clearer end.

Certain Defects in Working of a Mule.[1]

(*a*) The usual cause of too much yarn backing off is having a slack backing-off chain, and this feature becoming more pronounced as the cop builds up implies the absence of an automatic backing-off chain tightening motion and neglect of the spinner to tighten the chain by hand, or else the automatic motion is not properly adjusted. A wrong outline of backing-off snarl sometimes affects this problem.

(*b*) If the carriage is coming irregularly on the catch it may be due to one of the following causes: (1) Engine running irregularly; (2) too much strap-relieving motion at work; (3) back-shaft box sticking; (4) long lever sticking or not being changed at the correct

[1] For further discussion on cotton mules readers are referred to Vols. I. and II. "Mule Spinning" by present author.

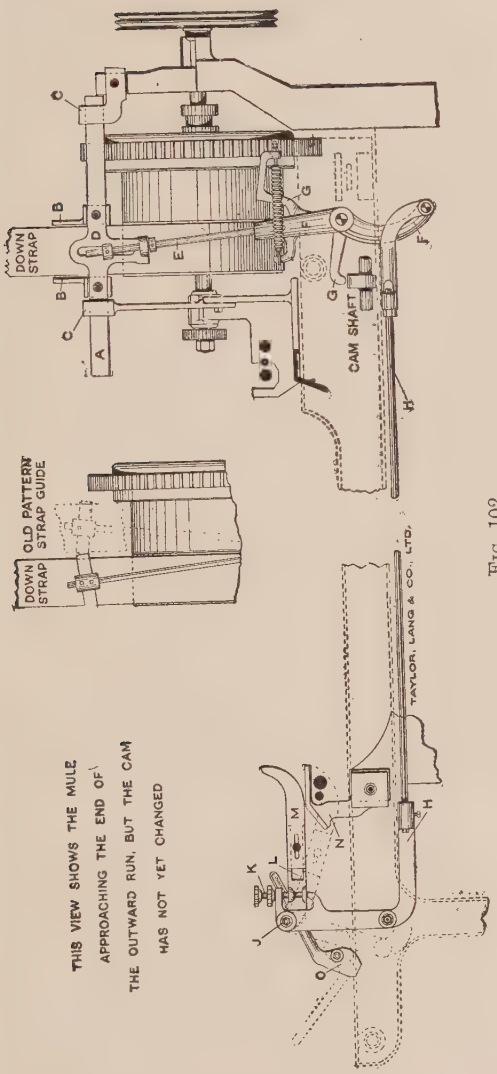


FIG. 102.

References to Diagram (Fig. 102).

A Slide bar.
B Strap guides (adjustable).
C Brackets in which slide bar traverses back and forth.
D Adjustable fulbow working in slot in slide bar.
E Connecting rod from strap lever to slide bar.
F "Loose" part of compound strap lever.
G "Fast" part of compound strap lever, actuated by cam shaft.
H Strap relieving rod connected to "loose" part of compound strap lever.
J Pendant lever on front of head stock.
K Special adjusting screw for (J).
L Strap traversing lever.
M Adjustable bayonet on (L).
N Incline on carriage square.
O Eccentric lever for holding strap on loose pulley.

moment; (5) holding-out catch not properly set; (6) tendency of winding catch to engage prematurely; (7) carriage not set properly "square" or parallel with the roller beam; (8) front

stops not properly adjusted: (9) back shaft inclines not used in a correct and equal manner; (10) very slack down strap combined with too much strap drawing-off.

(*c*) Counter faller too high at the termination of inward run is usually accounted for by such circumstances as the following: Too much governing motion in use; too small an amount of nosing motion; depression levers not used sufficiently and equally; quadrant arm set too far back; wrong profile of copping rail.

(*d*) "Winding under" during the formation of the cop bottom is often caused by the cop bottom being too heavy, or by the shaper being stopped during the first several draws, or by want of a sufficiently defined apex on the copping rail or a sufficiently developed first fall in the rail, or by the threads becoming too slack and the counter wire lifting too much, or the bottom cone in the cop too short, or the first "chase" of the faller wire being too short, or an excessively slack backing-off chain, or an excessive use of faller-easing motions, or faller weights touching the floor.

Parallel Strap Guide Motion.

The superiority of this motion to the old radial type (see inset) is obvious. All tilting of the strap eye is eliminated, and a plain horizontal motion substituted, resulting in considerably less wear and tear upon the edges of the strap.

Strap Traverse Motion (Fig. 102).

This is known as strap relieving or drawing-off motion. The object of the motion is to move the down strap from the fast to the loose pulley on rim shaft, as the carriage approaches the end of the outward run, before the cam changes.

This movement of the strap on to the loose pulley is made possible by the construction of the strap levers (F) and (G). The "loose" strap lever (F), which carries the strap rod (E), is connected by rod (H) to pendant lever (J) at front of headstock. Upon the same centre is a lever (L) terminating in a curved, adjustable bayonet (M). When the strap is on the fast pulley this lever occupies position shown by dotted line, but as the carriage completes its outward run, a bracket (N) on the square lifts lever (J) and forces strap on to loose pulley.

The movement of the strap on to loose pulley may be begun sooner or later by lengthening or shortening lever (L, M). The amount of drawing-off is regulated by screw (K). When this is locked as in diagram, the whole movement of lever (L, M) is transmitted to strap lever (F), and the strap is brought entirely on to the

loose pulley. By adjusting (K), any desired degree of drawing-off (to suit the running of the mule) may be readily obtained without use of screw keys.

Handle on Headstock Side for Stopping Mule (Fig. 102).

The eccentric handle (O) may be used either to retain strap on loose pulley when mule runs up to roller beam or to rapidly bring carriage to a standstill at any stage of its outward run. It is extremely useful when oiling or cleaning loose pulley on counter shaft with belts running.

A quick and positive method of operating the changes in the self-acting mule headstock is obtained by the cam shaft, and the various changes in the working of the Taylor Lang headstock are controlled by the cam shaft illustrated in diagram.

In the latest improved headstock the cam friction has been brought out in front of the pedestal, where it is easily accessible for adjustment and where its changes can be readily observed.

The various eccentrics which move the levers actuating the motions are cast solid with the cam shell (C), and therefore cannot possibly be displaced from their position relative to each other.

Special attention is directed to the improved method of attaching the steel dies and inclines which can be easily removed in case they require renewing, all that is necessary being to loosen the set-screws locking them in position. (*Cam-shaft*, Fig. 103.)

The cam shaft illustrated in diagram makes two half revolutions per draw, the first of these taking place at the end of the inward run, and the second at the conclusion of the outward movement of the carriage. The friction cone (G) is keyed to cam shaft (A), and revolves during the whole of the time the mule is working, being driven positively from the backing-off wheel through cam shaft (A) and wheel (B). The leather part of friction (D) is connected through disc (F) with the cam shell upon which it slides, and is forced by spring (H) into gear with friction dish (G) at each change of the long lever. When the cam shell (C) has made a half revolution through the friction being engaged, the steel dies (E) upon friction (D) are brought into contact with a steel incline (U) upon the bracket (T), carried by the long lever (P), and the friction is thus lifted out of gear with dish (G), and comes to rest.

Roller Delivery Motion During Winding (Fig. 104 on left hand).

This motion will deliver $3\frac{1}{2}$ inches of roving during the inward run of carriage. It is driven from the back shaft through a carrier gearing with wheel (D) on left-hand side of the headstock. The intermittent motion is obtained by the use of a click wheel and click.

Roller Delivery Motion During Twisting at the Head.

The object of this motion is to deliver a short length of roving to counteract the tension in the yarn caused by insertion of twist

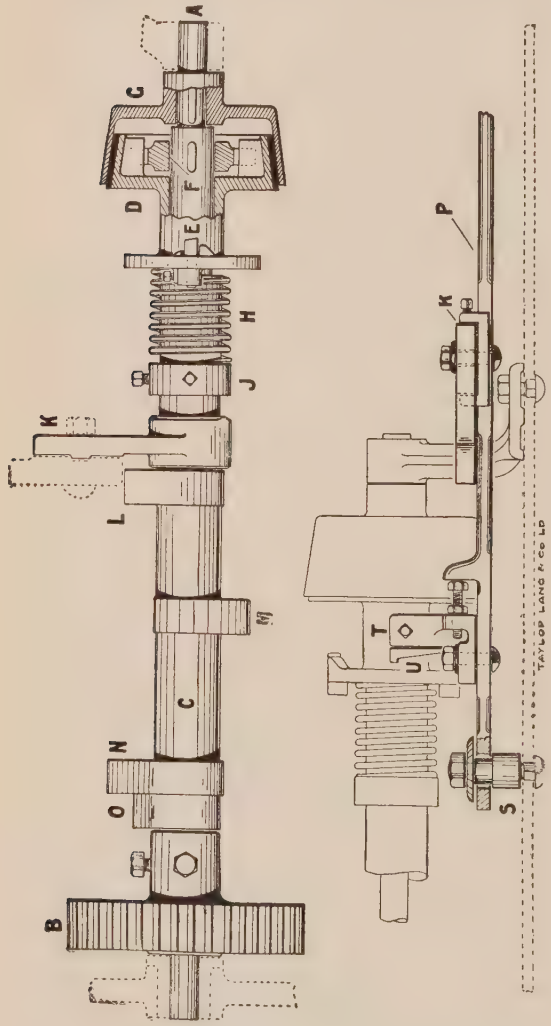
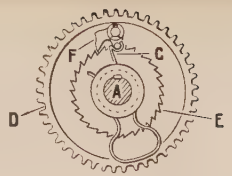


FIG. 103.

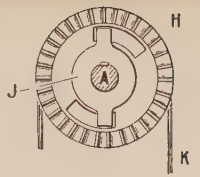
Cam Shaft and Long Lever (Fig. 103).

A Cam shaft.
B Driving wheel on cam shaft (A).
C Cam shell carrying eccentrics.
D Cam friction (leather part) sliding on shell (C).
E Steel die in cam friction.
F Disc keyed on cam shell (C).
G Cam friction dish keyed on shaft (A).
H Cam friction spring.
J Spring collar.
K Middle bearing for cam shaft on pedestal.
L Front spindle catch-box eccentric.
M Strap lever eccentric.
N Back shaft catch box eccentric.
O Taking-in friction eccentric.
P Long cam change lever.
R Incline on long lever.
S Guide bush for long lever.
T Adjustable die bracket bolted to long lever.
U Steel incline engaging with die in cam friction.

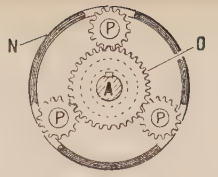
after outward run is completed. The amount of delivery can be regulated to suit class of yarn to be produced.



ROLLER DELIVERY MOTION



ANTI-SNARLING MOTION



IMPROVED JACKING MOTION

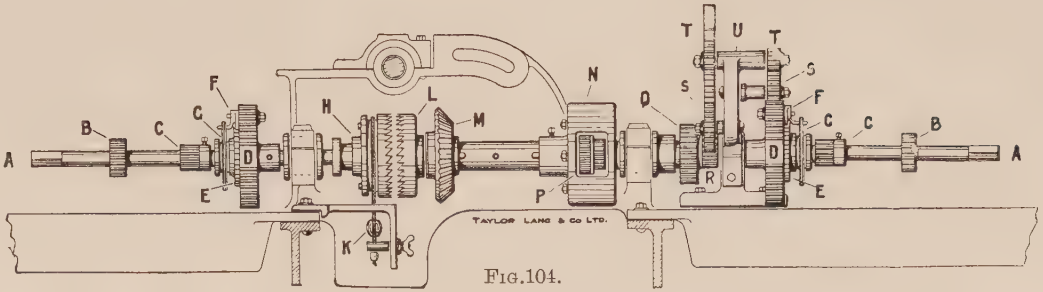


FIG. 104.

Front Spindle for Fine Mule.

A Front spindle.
B Pinion driving fluker shaft.
C Pinion driving rollers.
D Roller motion wheel.
E Roller motion click wheel.
F Roller motion catch.
G Roller motion spring.
H Sliding part of catch box.
J Disc driving front spindle.
K Weight and lace for anti-snarling motion.
L Driving half of catch box.
M Bevel on long cannon.
N Jacking motion box.
O Jacking motion wheel on front spindle.
P Jacking motion compound wheels.
Q Carriage driving pinion on jacking cannon.
R Pinion on jacking cannon driving roller delivery motion during twisting.
S Roller delivery motion carrier wheels.
T Roller delivery motion change wheels.
U Bracket carrying roller delivery motion gearing.

Anti-Snarling Motion (Fig. 104, Centre).

This motion delays the delivery of roving from the rollers so as to draw out any snarls which may have been left upon the yarn at the end of the previous draw. When the catch box disengages, the sliding portion (H) is pulled backwards by lace and weight (K) to an amount determined by the setting of the adjustable stud shown in diagram. Upon re-engagement of the clutch at the beginning of the draw the rollers loose the fraction of a revolution represented by the above-mentioned backward movement of catch box (H).

Improved Jacking Motion (Fig. 104, Right Hand).

When the front roller catch box is disengaged, the jacking box (N) continues its revolution at normal speed, being keyed upon front spindle cannon The compound jacking pinions (P) are carried forward with it, and since they gear with wheel (O) keyed upon front spindle (now stationary) they acquire an epicyclic motion. The result is that the jacking cannon upon which is carriage driving wheel (Q) is driven forward at one-fifth the normal front spindle speed.

In the improved jacking box, three pinions are now employed, greatly reducing wear and tear.

Copping (or Builder) Motion (Fig. 105).

In this copping motion the rail is much shorter than in the ordinary type; the distance between the main centres is now 54 inches, as compared with the usual 70 inches. This means that the rail is stiffer and less liable to deflection, the result being a firmer and better built cop.

Any adjustment of the three plates may readily be made by means of the studs which fit into connecting rod (J). The rail and loose incline are adjusted by taking out the small cast-iron blocks which carry them upon the plates, and turning the square-headed screws the number of quarter turns required to give desired alteration to chase, or to depth of locking. The heads of these screws fit snugly in the square holes in ends of rail and loose incline; once the blocks are replaced in position the screws cannot possibly alter their setting.

It will be noted that the rail is supported at its front extremity on plate (G) by a solid pin, and that the adjustment is made at the block resting on back plate. This enables any alteration of chase to be made without re-setting the bootleg, for the ridge of the rail is never disturbed.

Another point of interest is that a vertical guide bracket (E) is used in place of the usual inclined bracket or "pigs-foot." This

inclined bracket is thought by many to be an essential feature of a copping motion, but a vertical bracket is simpler and more satis-

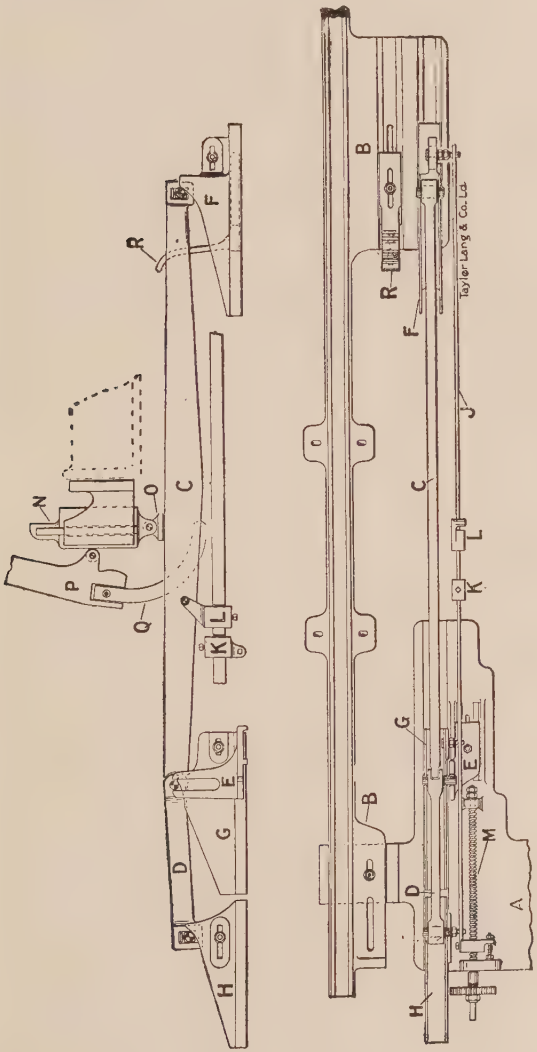


FIG. 105.

A Headstock foot carrying front plates.
B Copping slip carrying back plate.
C Copping rail.
D Loose incline.
E Guide bracket for rail.
F Back copping plate.
G Front copping plate.
H Locking plate.
J Connecting rod.
K Nosing motion fibow.
L Backing-off chain tightening motion fibow.
M Shaper screw.
N Slide block on square.
O Trail slipper on (N).
P Bootleg.
Q Bayonet for unlocking bootleg.
R Unlocking bracket on copping slip.

factory. Again the quadrant should be vertical when the trail block passes over the ridge of the rail so that the least amount of

winding occurs on the biggest diameter of cop. This relationship should remain constant throughout the set, and is only possible with a vertical guide bracket; with older types of inclined bracket the position of the rail varies continually from start to finish of the cop.

The above copping motion has now been at work for nearly thirty years and has proved satisfactory (July, 1922).

The more usual method with machine makers is to apply inclined steady brackets and vertical setting screws at the front. Both methods give good results.

Copping Alterations (Fig. 106).

(1) The back plate brought inwards half an inch; (2) the vertical screw, which carries the front end of the rail, moved downwards four complete turns.

1. If the back plate were brought in it reduces the inclination in the copping rail, leading to—

(*a*) Shortening of the chase of the cop rather substantially all through the set of cops, but the shortening effect would be far the greatest for the first few minutes after doffing.

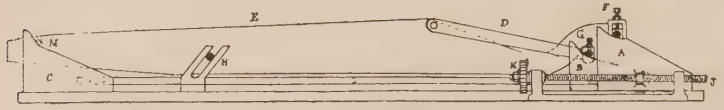


Fig. 106.

(*b*) It would make the bottom cone of the cop longer and thinner, owing to the total fall of the rail being made greater during the time that the copping rail is resting on the coning incline of the front plate.

(*c*) Except in the case of the bottom cone, the cop would be made very slightly thicker, as this is an effect which follows shortening of the chase.

2. (*a*) By screwing down at the vertical copping rail screw, broadly speaking the opposite effect is produced to that by pulling in the back plate, i.e. the inclination of the copping rail is increased.

(*b*) This would lengthen the chase in an equal proportion all through the set.

(*c*) It would make the cops somewhat thinner. It must be noted that altering the position of the back plate may affect the length of the bottom cone of cop, which is not the case with altering the vertical screw; also that variations in the length of chase may affect the depth of faller locking.

Again, while alterations in the back plate affect the length of

chase far more for the first few minutes after doffing than when the cops get larger, alterations by the screw give equal proportions through the set.

A is the front plate; B is the middle plate or loose incline plate; C is the back plate; D is the loose front incline of copping rail used to regulate the depth of lock and the amount of crossing thread; E is the long and principal incline of the copping rail; F is the vertical screw by which the length of cop chase is regulated; G is the vertical screw by which the relative inclination of the loose incline, D, is regulated, and consequently by which the depth of faller lock is determined; H is the steady or stay bracket, by which the copping rail is kept firmly in position, although quite free to move upwards and downwards. J is the front extremity of the builder motion worm with the builder wheel, K, at its inside extremity; M is the stud by which the rear end of the copping rail is sustained on the back copping plate.

To Remedy Copping Defects.

(1) Thinner at the top of the cop than the bottom, and long cop nose. (2) Long chase during early draws. (3) Short stiff bottoms causing running under and short chase.

1. In many cases when cops are thinner at the top than at the bottom, and there is a longer cop chase at the top than the bottom than there ought to be in proportion, a remedy may be effected by alterations in the sector. It may be stated that when the centre of the sector stud is in the same horizontal plane as the centre of the winding faller shaft, the winding faller wire should be in the centre of the working length of the spindle blade in order to give a parallel cop. By placing the sector stud in position indicated and then lifting the winding faller wire an inch or more up the spindles we should expect an improvement to result in the cops under discussion. Another remedy might be to have less of the front copping plate in action so as to thin the lower portion of the cop, while the chase could be shortened by the vertical screw of the copping rail.

2 Long chase during early draws is usually caused by having an insufficient amount of the back plate working. Owing to the shape of this plate if we drew it in to have the rail resting on a higher portion of the plate the chase will be shortened all through the building of the cops, but far more during the early draws than at a later stage.

3. The statement may be taken as referring to either the portion of cop made during the early draws or to the bottom cone of the cop.

Suppose the cop bottoms as made during the early draws were short and stiff, then running under might occur during the first

few minutes. A remedy might be found by pushing the back plate a little bit out of action so as to lengthen the bottom. If the chase is short all through the set, then it might be lengthened by raising the front end of the copping rail by means of the front vertical screw of the rail. Taking the question as in coning that the bottom cone of the cop is too short and stiff, then the remedy might be found in putting more of the back plate at work and keeping the front plate as before, as this would lengthen out the bottom cone and make it proportionately thinner owing to the fall of the copping rail being increased while only the same amount of yarn is put on the bottom cone as before. The chase could be altered by the front vertical screw of the rail as before.

Mule Cop with Concave Body or Cylinder.

When a mule cop varies in diameter of cylinder it is more frequently the case that they gradually taper thicker or thinner upwards, without again recovering the original diameter. A concave or convex cop cylinder is less usual. Such defects, however, we have frequently witnessed. When cops vary in diameter or "squareness" of body it will be usually found that the defect originates from the plates. In the case under discussion, having first ascertained that there was nothing loose or badly worn about the copping parts, and granting that the defect exists in every set of cops being spun, it would probably be the best plan to at once make an examination of the plates. A sufficient knowledge of their correct configuration would enable us at once to tell whether they were correct in this respect or not, our examination extending, of course, both to the back and the front plates. We strongly recommend the possession of templets by overlookers, managers, fitters, etc., who may have to do with copping. These can be at once applied to the working surfaces of the plates, and any defects thereby shown up in an instant. A defect like the one mentioned in the question would probably emanate from the plates—either one or both of them—having too rapid a fall or incline at the point whereon the copping rail would be resting when the concavity in the cops was caused. It could be caused by a concavity or extra steep place in the back plate alone, which would cause the chase of the cop to lengthen at that portion and afterwards to shorten again, this being certain to result in the defect under discussion. To remedy it we could file the plates backwards and forwards towards the initial and terminal points from the concave portion in order to reduce the surfaces approximately to the same inclination, having regard to the fact that it is good practice to have the back plate rather less steep than the front plate in order to gradually shorten the chase and get more weight on the cops. In this filing,

as we have said, anyone who was not pretty sure of the effect of his filing would do well to work to templet, and even an expert would be assisted in his work in most such cases. Another way in which such a defect might possibly be remedied would be to put less coning incline of front plate at work, so as to thin down the base of the cop to the same diameter as the concave portion, after which the upper portion of the cops, might be thinned down by filing the back plate alone, or both plates, as the case might be, from the concave portion down to the terminal point. After the cops had been got right by filing plates, it is very probable that the shaper would require altering in size to maintain a correct diameter of full cop. In all such cases of copping the exact procedure which is best suited to any one case can only be determined by an examination of local conditions. In other cases, after putting a less amount of coning incline to work, we might drop the faller wire in relation to the sector, so as to thin the upper portion of cop. It may be noted that with short copping rails it has long been quite common to make the coning incline of the front plate straight, or even convex, and there is a tendency to adopt the same practice with the front plate for the long rail. Formerly this incline was made concave.

The Moorhouse drive for self-acting mules attracted considerable attraction about 1902. Results in application quite failed to justify anticipations. One long rope was made to drive directly from counter-shaft to rim-shaft and forward to the tin roller shaft. No down-belt was used.

General Defects in Mule Cops.

Generally speaking, the length and thickness of the bottom cone of cop is mostly affected by the proportionate amounts of back and front plates at work. The adjustment of the sector in relation to the winding faller wire is another important factor in these dimensions, and the problem is also affected by other minor considerations. (*a*) If the bottom cone of cop were too long and thick while the chase was also very long, we should first of all examine the front plate adjustment, and it is very probable we should find this with too much coning incline at work. It might be that too much of both plates were at work, and sufficient length of chase obtained first draw by having too much bevel in the rail. Afterwards the sector adjustment may be tested, as setting the winding faller too low in relation to the sector stud leads to thickening of the cops in the earlier stages, although it does not then lengthen the chase also as required by the question. (*b*) The defect of bottom cone too long and too thin is often caused by having too

much back plate only at work, as this increases the total fall of the copping rail during the formation of the cop bottom, without increasing the number of draws occupied in forming the bottom cone. Setting the faller wire too high in relation to the sector stud also exercises a distinct effect in the same direction. (*c*) Cops thickening as they build up with very short chase at finish is a defect often due to the winding faller wire being set too high in relation to the sector stud, and this setting should be examined first thing. Another very likely cause of such a defect is the back plate having an insufficient amount of inclination after the cops are half-way built, as this infallibly leads to shortening the chase, and this is usually accompanied by thickening of the cops. (*d*) Ridgy cops are often due to the want of sufficient smoothness in the copping rail, copping slips, studs in the copping mechanism, or other allied parts, and these should all be checked and made right in this respect. Faller shafts working with perfect steadiness and freedom is a good guarantee of smooth build in the cop, and anything interfering with such working should be at once remedied. Tin rollers should not be allowed to run so unsteadily as to vibrate the mule. The copping rail, shaper screw, copping plates, and allied parts should have all requisite freedom, combined with sufficient firmness in position. An excessive taking-in speed of carriage may lead to a rough build in the cops, and the same may be said of faulty operation of the taking-in friction. It is better also that the backing-off friction shall not bind in running up.

Specifications of Modern Mules.

Self-Acting Mules Suitable for Spinning any Counts of Yarn.

(Messrs. Dobson & Barlow.)

Made for 52 inches, 54 inches, 56 inches, 58 inches, 60 inches, 62 inches, 64 inches, 66 inches, 68 inches, 70 inches or 72 inches draw, according to the numbers to be spun.

The claims made for this mule by the makers, are :—

"Simplicity of construction; neatness in design combined with strong and well-proportioned patterns. The different motions and change places are most easy of access; all jointings are planed or milled; and all parts are interchangeable, being planed, tongued, grooved, and finished to template by special tools.

"The principal borings are all done to template and at one operation, by a special machine; this gives the greatest accuracy and facility in setting and erecting, as the bearings or supports when once bored cannot get out of 'truth.' The utmost steadiness

and freeness are thus obtained, together with light and noiseless running, highest speeds, and greatest production.

"With these advantages less driving power is required; the repair cost is reduced to a minimum; absolute rigidity is ensured, and total absence of vibration.

"The headstock, middle slips, copping motion, outside quadrant support and drawing-up scroll bearings are all fixed on long extra-strong cast-iron, planed foundation plates, which combine the whole in the most perfect and rigid manner.

"The quadrant slide is fastened to the sector with tongues and grooves instead of being in one part, so that in case of replacement less expense is incurred.

"Each motion is separate and distinct, is easy of access, and perfectly controllable.

"The changes are effected by a strong wrought-iron lever.

"Ordinary or patent 'Duplex' driving arrangement.

"Automatic band governor or strapping motion, suitable for all counts of yarn. The cop bottoms are made automatically, no assistance being required from the minder. Tight and regular winding is also ensured during the building of the cop bottom. All strain upon the yarn is avoided, it being always at one uniform tension. Snarls, cut yarn, and waste prevented. For fine counts of yarn, which require the least possible weight on the fallers, the motion shows a great sensitiveness to the difference in tension of the yarn.

"Automatic nosing motion, which gives absolute certainty of a perfectly-formed cop nose. Tight and regular winding throughout the entire length of a cop is obtained and an increased length of yarn is put upon the cops. Slack winding, ruffled or fussy noses, bad cops, and waste entirely prevented. Less doffing is required; winding frame production is increased at less cost. It is self-adjusting, and is suitable for all kinds and variations in taper of spindle blades.

"Self-acting strap relieving motion. It is very simple, and arranged so that the driving strap can be easily moved from the fast to the loose pulley, when working with or without twist motion.

"Improved backing-off motion with extra large size backing-off cone, 20 inches diameter, which gives increased command over the rim shaft, thereby stopping it easily, though instantaneously, thus causing a gain of time in changing.

"Drawing-up and backing-off motion driven by rope or strap.

"Improved long or short copping rail.

"Improved full-cop stopping motion; cops of any length or containing any number of draws can be made with this motion. This motion is more particularly used for weft cops.

"Safety or stopping motion, to prevent accidents or breakages in the mule should anything by accident get in the way of the carriages during their outward run; also an arrangement for stopping the carriages instantaneously during their inward run, if required.

"Tin roller pulleys in halves.

"Tin roller blocks with hardened steel arbors and fixed brass bearings.

"Large diameter of rim-carrier pulleys.

"Swing pulley frame to take up slack of rim bands.

"Carriages of extra strong construction.

"One, two, or three threads to each boss of roller.

"Cap bars with fast or sliding neb.

"Improved travelling scavenger motions.

"Mules made with rim at back or at side.

"Bottom rollers case-hardened all over, or in the necks and squares only.

"Top rollers with or without loose bosses.

"Patent carriage gear motions.

"Indicators for draws or hanks.

"Bottom and top rollers of own manufacture, recognised by the trade as very good. Special fluting and other details for delicate and difficult cotton.

"Spindles of own make, made from specially selected steel to stand the highest speeds.

"Special arrangements for self-lubricating the bolsters and footsteps.

"All revolving parts exactly balanced.

Additions for Spinning Fine Counts.

"Improved after-stretch motion, complete absence of back lash.

"Improved winding motion.

"Improved roller turning motion whilst twisting at the head.

"Double-speed driving apparatus.

"Improved faller lifting motion.

"Faller shafts on anti-friction bowls.

"Headstock and other packings, headstock and back shaft scroll guards and dripping tins, are charged extra.

"There are supplied, free of charge, with each mule twelve front top rollers; also the following changes with each mule, including those on the machine: six draft wheels, three twist wheels, three back change or speed wheels, three drag or gain wheels, three shaper or builder wheels, and two rim pulleys."

Specification.

When ordering new mules to be filled in by spinning firm.

No. of mules. No. of spindles.
Space of spindles. Length of spindle.
Length of spindle out of bolster. Dia. of wharve.
Travel of carriage. Rollers deliver whilst winding ins.
Double / Single } Speed. Revs. of line shaft per minute.
Dia. of drum on same—double speed. Single speed.
,, pulley on counter shaft for—double speed. Single speed.
,, drum on counter shaft. Revs. of rim shaft per minute.
,, front bottom roller. / ,, middle ,, ,, / ,, back ,, ,, } Dia. of single, double, treble boss top roller, uncovered.
Weights. Under clearers, fluke rods.
Backing-off and drawing-up motion by strap.
Winding motion by strap.
Nosing motion. Governor motion.
Kind of cotton to be worked. Counts to be spun.

Notes.

Approximate Power.—Mules for Indian, American, and low classes of cotton, 120 spindles to 1 i.h.p. Mules for Egyptian and better classes of cotton, 130 to 140 spindles to 1 i.h.p.

Driving Pulley.—16 inches diameter for 4 inches, 4½ inches, 5 or 5½-inch straps. "Duplex" for 2½ or 3-inch strap.

Space Occupied.—Multiply the number of spindles in the mule by the space of spindles, and add 6 feet, or 1·83 m., the rollers being geared at headstock.

Strapping Required (for double-speed driving). — Line shaft to counter shaft, 100 feet × 5 inches. Counter shaft to headstock, "Duplex" driving, 48 feet × 2½ or 3 inches.

(For single-speed driving).—Line shaft to counter shaft, 50 feet × 6 inches. Counter shaft to headstock single speed driving, 24 feet × 4, 4½, 5, or 5½ inches. Winding motion strap, 24 feet × 1½ inch. Drawing-up strap, 26 feet × 2½ inches.

Banding.—It is important that in order to ensure the good working of the mules, the following diameters of bands must be used: For double-grooved rim, $\frac{9}{16}$ inch; or for treble-grooved rim, $\frac{7}{16}$ inch; back shaft drawing-out scrolls, and counter shaft to drawing-up and backing-off shaft, $\frac{9}{16}$ inch; for drawing-up scrolls, drawing-up coarse scroll on back shaft, quadrant, and for check scrolls, $\frac{7}{8}$ inch; for governor motion and squaring band pulleys underneath carrier, $\frac{3}{8}$ inch.

Banding requi red) fordouble-speed driving).—70 feet of $\frac{7}{8}$ inch, 248 feet of $\frac{9}{16}$ inch, and 117 feet of $\frac{3}{8}$ inch. Spindle banding, 393 spindles to 1 lb. of banding. Length of band, 3 feet 5 inches when pieced.

Banding required (for single-speed driving).—70 feet of $\frac{7}{8}$ inch, 286 feet of $\frac{9}{16}$ inch, and 117 feet of $\frac{3}{8}$ inch. Spindle banding, 393 spindles to 1 lb. of banding. Length of band, 3 feet 5 inches when pieced.

When drawing-up by strap is used, only 248 feet of $\frac{9}{16}$ inch banding required.

To Shorten a Mule Stretch.

We will assume it is desired to shorten from 64 inches to 62½ inches, same counts of yarn. It is unlikely we should alter the back stops or distance from spindle point to nip of roller, so we could close in all the front stops 1½ inch, to prevent the carriage from coming as far out. Move the stud for the holding-out catch 1½ inch farther out, or else the catch 1½ inch farther in. The long lever must be changed first time 1½ inch sooner, and the requisite bracket moved correspondingly. The copping rail bowl should be brought a little farther out, or else the rail itself moved inwards somewhat, although not necessarily the full 1½ inch. This would maintain sufficient of the loose front incline of rail at work. Attention must be paid to the readjustment of such details as floor inclines for salmon head levers, the operation of the shaper wheel, winding faller depression, incline for tightening the backing-off chain, in order to make all such parts operate sufficiently keen with the shortened stretch. In some makes of mules the rod for opening the roller box would require changing proportionately sooner, but in cam shaft mules this would depend upon the changing of the long lever. Some people would prefer to set the quadrant a little farther back. In most mules an important readjustment would be necessary in regard to the engagement of the backing-off friction, the charge rod requiring to be operated sooner from the proper finger or fish jaw lever in the carriage square. In particular makes of mule other details might need attention, and in all makes it would probably be best to re-adjust the back shaft scrolls, and also those on the drawing-up scrolls, or otherwise scarcely enough of these would be put in use when the carriage was fully out. If a supplementary twisting motion were used the twist wheel would require altering to give rather less total revolutions per stretch to the spindles. Providing the full sweep of the quadrant were required for shortened stretch, it might be better if a tooth larger quadrant pinion were put, although it would probably be a matter for experiment as to which pinion would give the best

results. It may be pointed out that a short copping rail lends itself to alterations in stretch length better than a long one; for example, changing the larger half of the Montgomery wheel from forty to thirty-nine teeth would maintain the full use of copping rail with reduced stretch.

Backing-off Friction.

If the backing-off friction of a mule fails to gear properly the mule simply stops at the head until the requisite steps are taken to start it off again. The friction keeps on rotating, but cannot take the rim shaft round because of imperfect engagement. (Care should be taken to distinguish between this action and the mule stopping by the winding click prematurely dropping into gear.) The taking-in rope would rotate the loose halves of the cam and drawing-up clutches also. There are many causes of imperfect engagement of the backing-off friction, such as not being set sufficiently deep, the stop on the strap fork not moving far enough out of the way, the backing-off spring being too weak or too slack, the various levers not being centred correctly, the carriage not getting far enough out. Providing slipping were not due to any of these causes, it might be due to the friction being badly covered, or greasy or poor leather, etc. The precautions necessary to ensure proper working are to guard against such evils as above specified.

Filled in Specification.

To spin 120's from Egyptian cotton. (*a*) Speed of spindles, (*b*) gauge of spindles, (*c*) diameter of all bottom and top rollers, (*d*) whether solid or loose boss top rollers front line, (*e*) how many ends to boss, (*f*) draft of rollers between front and middle and between middle and back, (*g*) distance centre to centre of different lines of rollers, (*h*) lever or dead weighting, stating weight in either case, (*i*) length of stretch, (*k*) gain of carriage.

Different firms would give different particulars to many of the above points so that the answers given below must only be taken as approximating to general practice. Single speed of spindles, 6,000 r.p.m., and double speed, 9,500. Gauge of twist spindles, $1\frac{5}{16}$ inch. Diameters of bottom rollers: Front and back, $1\frac{1}{16}$ inch, or $1\frac{1}{8}$ inch, and diameter, middle roller, $\frac{7}{8}$ inch. Diameter of top rollers: Front overall, $1\frac{1}{4}$ or $1\frac{3}{8}$ inch; middle $\frac{3}{4}$ inch; back, 2 inches. Solid roller front top line. One end or thread to each boss. Draft of rollers between front and middle, say, 12, and between middle and back, say, 1·08, giving a total of 12·96. Distance centre to centre of back and middle rollers, say, $1\frac{5}{8}$ inch or $1\frac{3}{4}$ inch. Distance centre to centre of front and middle, say, $1\frac{3}{16}$ inch. Dead weighting, giving about $2\frac{1}{2}$ lb. on front line per individual thread, 2 ounces on the

middle, and, say, 6 ounces on the back roller per thread. Length of stretch, say, 58 or 60 inches. Gain of carriage, say, 5½ inches. The mule should have on the motions special to fine spinning, such as ratching motion, winding and jacking roller delivery motions. Double speed, belt taking-in, and rim motions might be left to the special opinions of the buyer. The hank roving would be found by a calculation taking into consideration the amount of ratch and gain, twist per inch, double roving, counts spinning, and roller draft.

Bad Spinning and Bad Winding.

During the outgoing of the carriage bad spinning may be caused by poor cotton, badly made bobbins, dirty or irregular rovings, defective condition of rollers, as regards setting, weighting, leather covering, over-drafting, etc. There may be too much or too little twist, too much "gain" or "ratch," or too high a speed of the carriage spindles and rollers. The traverse motion may be wrong. In very frosty, or in dry hot weather, we may expect the threads to break very readily, and this evil is accentuated by the facility with which the cotton licks on the leather rollers.

Defective winding and thread breakage during winding may be caused by the following circumstances: Over-weighting of fallers, slippage of taking-in friction, slippage of winding-on click, too much nosing motion, not enough governing motion, defective copping or wrong setting of quadrant, weak carriages, diagonal rods and back shafts, and faulty adjustment of the various cords or bands. Some of the faults enumerated for carriage coming out also act detrimentally on the threads during winding-on. The foregoing are all more or less common faults, but do not exhaust the subject.

General Overhauling of Mule.

In a general overhauling of the mule it would be necessary to renovate various parts of the headstock, and attention might be devoted to this at the outset. Advantage should be taken of the opportunity to replace all badly worn wheels, or broken studs, brackets, and other parts. The various frictions should be recovered, or at least skimmed up, and the various parts and framework of the headstock levelled up.

At an early stage we should turn our attention to the roller beams and roller stands and rollers. The roller beam should be thoroughly levelled up, and any worn brasses in the stands of the iron rollers should be replaced.

Roughly speaking, for repairing and re-setting purposes, a mule may be divided into three portions: (1) The headstock; (2) the

roller beam and all connected parts; (3) the carriage and all connected parts.

Referring now to the carriage and its parts, we have to deal with the slips, the lining up of the carriage, the height of the carriage, or what is the same thing, the height of the spindle points, the bevel of the spindles, the faller shafts, the faller sickles and wires and the tin rollers, which could be probably taken in the order stated. The parts which require most attention are such as above given.

In some cases after new mules have been working only a few months some people like to overhaul them slightly, the operation then consisting mainly in re-screwing and re-lining some of the parts.

Small Snarls in Cop Nose.

One of the developments in the copping rail of a mule was to make the front incline much longer with the definite object of burying in the "chase" any snarls which may happen to be on the spindle points just prior to backing-off. An important object also of the long incline is to get a steady downward movement of the winding faller, in order not to break the threads.

The long front incline was already popular in 1890, when first operated by the present author.

The causes of snarls are exceedingly numerous, and the author has dealt with the subject elsewhere at great length. In a note of this kind it is quite evident that only the leading causes of snarls can be mentioned. These may be briefly enumerated as follows: (*a*) Fallers unlocking too soon; (*b*) an insufficient amount of "gain" in the carriage; (*c*) the nosing motion, anti-snarling motion or hastening motion not being sufficiently at work; (*d*) the quadrant nut too high; (*e*) the faller wires being badly set, or the carriage not "lighting-in" squarely, etc.

Bevel in Mule Spindles.

By bevel, of mule spindles, is meant their inclination from the vertical. This is rendered necessary in order to allow the yarn to twist off the spindle points without breaking. Its amount may be determined or measured by dropping a plim line from the apex of the spindle and measuring the distance from the foot of the spindle to the line. There are specially constructed gauges for fixing the amount of bevel very readily. If it is required to be altered the following method might be adopted: Set a few spindles at the headstock to the bevel required by measuring the difference between foot and apex of spindle as indicated above. Then set the spindle bevel gauge to these spindles. Adjust a few spindles at the other side of the headstock and at each mule end by the gauge. Extend

a string the full length of the mule a little above the correct spindles. Then proceed to set the bevel of the spindles from one end of the carriage to the other by means of the string and the gauge combined. The gauge shows whether we have the correct amount of bevel on the spindles, and the line of string shows whether we have the spindles all one distance from the rollers, or in other words, in a horizontally straight line. The bevel, of course, is adjusted by means of the carriage stays or rods, which are connected to the carriage at the back, and either to the top or bottom spindle rails at the front. More bevel may be put in either by the top rail being pulled in or the bottom rail pushed out by the screwed rods. The string along the tops of the spindles will assist in determining which of the two must be adopted. There is generally more bevel in weft mules than in twist of the same

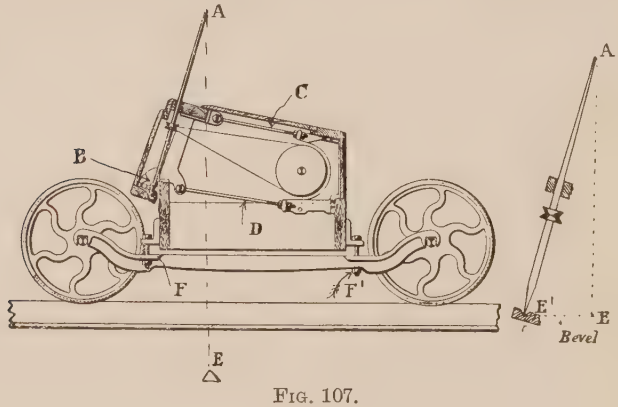


Fig. 107.

counts, particularly when the lengths of the spindles are compared. This is because of the softer nature of the weft yarn, as taking bevel out or strengthening the spindles somewhat always puts more strain on the yarn. The finer the counts the greater the amount of bevel necessary. A good rule for medium yarns is to put in a quarter inch of bevel for every inch of spindle, and, according to this, a 17-inch spindle would have $4\frac{1}{4}$ inches of bevel. If there is too much bevel in the spindles, snarls will result, and because of this in many firms the amount of bevel in their spindles has been reduced during recent years. If this procedure is carried too far of course it results in an excessive breakage of the ends. Bevel is most necessary when the carriage is nearly at the limit of its stretch, and least necessary when it is near the back stops, and if very easy and simple apparatus could be effectively applied for varying the amount of bevel as the carriage made its outward

journey, it would doubtless receive wide adoption. The inclined slips once tried in Hyde were intended to do this, but these "switchback" mules were accompanied by corresponding disadvantages to such an extent that they have met with no favour. Fig. 107 illustrates the parts requisite for an understanding of spindle bevel and its alteration. A, is the spindle point; B, the spindle footstep; C, the top stay rod used for alterations in bevel; D, is the bottom stay rod, used also for alteration of bevel; A, E is a vertical line used to show that by spindle bevel is meant the horizontal distance, E, E′, from spindle footstep to the line. The wood bolster and footstep rails are capable of moving about as required by the rods, C, D. By having two rods, C, D, we can more readily keep all the spindles in a straight line, as well as have the right bevel. F, F′ are the vertical rising screws, by which the "topping" or distance of spindle points from roller nip is regulated, and used sometimes to alter the bevel. On rare occasions spindle bevel is altered by putting in a different size of carriage wheels.

The Mule Change Wheels.

Promising arrangements have been tested with a view to superceding the ordinary draft wheels, so as to obtain more scope in amount, convenience, or fine degree of change.

Battersby's device compounded the broad carrier of back and middle rollers into one of the main train of draft wheels, and gave great convenience for the crown wheel or first driven wheel becoming the draft change wheel. The present author devised and applied a worm and worm wheel drafting combination. Neither device has received much adoption. The ordinary four-draft wheels retain their supremacy owing to modern improvements. Cut wheels of 18's diametral pitch give smaller wheels, increased convenience in obtaining a fine change, more accurate drafting, and fewer breakages than the older style of cast wheels of twelve or fourteen teeth per inch of diameter, applicable alike to mules and ring-frames.

On the ring-frame in some cases the broad carrier has been placed beneath the small back and middle roller pinions, and this enables the setting to be seen better. There are yet many cases of bad work due to faulty setting of the broad carrier for driving the middle roller although the use of flash-lamps often helps in noting this adjustment.

A very fine development in the ordinary four chief draft wheels consists in providing a central bearing for the crown wheel and ordinary driving change pinion. This enables the crown wheel or first driven wheel to be used as the change wheel if desired. Using this middle bearing and also cut wheels of 18's diametral pitch enables

almost any desired fineness of draft change to be made, as, for example, a crown wheel of 160 teeth to spin 160's counts of yarn, so that a 161's wheel would give 161's counts. One of the virtues of using the crown wheel as the change wheel is that it runs with the counts so that a larger or smaller wheel gives larger or smaller counts of yarn.

In the opinion of the author a feature worth extended adoption is to reduce the size of both driving change pinion and also of crown wheel excepting in fine counts.

The change pinion has for years been increased in size in order to get a finer degree of change, but this is no longer necessary if the crown wheel becomes the standard change place. For example, instead of using a 60's change pinion and a 160 crown wheel, the same draft result is obtained by a 30 and 80 combination. The 80's wheel of fine pitch is then a convenient size of wheel for overlookers or others to carry about, and gives a fine degree of change.

A further distinct advantage of the smaller wheels is bringing the driving change pinion more over the top centre of the back roller wheel and thus giving a more downward thrust on the back roller. The author has seen many cases of the change pinion being so far behind the back roller wheel as to exercise a distinct and undesirable upward thrust on the back roller. The smaller driving change wheel would be available for more substantial alterations in counts as desired.

A further point may now be considered.

It is possible to obtain infinitely finer degrees of change than practice demands by altering two change wheels with judgment and good knowledge. The two wheels might be the change pinion along with either the crown wheel or the back roller wheel. Assume, for example, you are spinning 120's with a 40's change pinion and 60's back roller wheel. One tooth on the 40's would mean approximately three counts in the yarn, say 40 to 39, meaning approximately 123's. If we also change back roller wheel 60's to 59's this brings the counts back approximately to 121's.

The nearer the driving and driven change wheels approach each other in size the finer will be the change. The double change wheel principle has its danger of mixing the wheels and involving extra trouble and care in changing, and is perhaps more adopted in connection with driving and driven gain or drag wheels.

Even with a 90's driven gain wheel in a 64 inch stretch one tooth change represents more than $\frac{3}{4}$ inch difference in amount of gain. If a 90 × 36 compound gain wheel be used and changed for a 92 × 37 compound the two teeth of the large wheel would counteract most of the effect of one tooth on the small wheel and leave a very reasonable alteration in gain.

One good firm now make the carrier compound so that any

desired new combination of the double carrier may be obtained. Example; To change a 60 × 45 combination to a 61 × 46 gives only $\frac{1}{4}$ inch alteration in gain, whereas one tooth in 90 = $\frac{3}{4}$-inch change.

Changing to Low Twist per Inch.

When making an extreme change of counts, say from 24's to 8's, in which latter a very low twist per inch is wanted, there are different methods of reducing the twist. The first thing often suggested is to reduce the diameter of rim pulley as in smaller changes, but the rim pulley dominates backing-off speed as well as twist per inch, and a very small diameter of rim gives a very slow backing-off. The author has tried the smallest made—about 6 inches—with unsatisfactory results. Speed cones for separate driving of backing-off friction are available, but add to the mechanism and affect also the speed of the cam shaft.

In most mules the small pinion for driving the large backing-off wheel is in fixed bearings and scarcely a tooth change can be made.

The method mostly found best by the author is to move the driving pulley on the top counter shaft a little to one side and apply a split pulley of smaller diameter—preferably a wood pulley if the change is not permanent. It is not essential for the pulley either to be of wood or split. In the case of a new mule, makers are prepared to apply anything from about 20 inches to nearly 3 feet diameter as top counter shaft driver. If a mule were definitely put up to spin a very wide range of twists, it would be possible to put a stepped driving pulley on the counter shaft.

When a very small top drum is applied it reduces equally the speed of carriage, rollers, and spindles, but the speed wheel or drawing-out wheel affords facilities for making rollers and carriage fast enough again, although a larger carrier wheel is sometimes necessary.

The fast and loose driven pulleys on counter shaft may be from 14 to 22 inches diameter, but 18 inches is common, to take a 6-inch wide belt, with a shaft of 2 inches diameter.

Details.

The standard diameter of tin roller has been 6 inches for many years, but 5 inches is sometimes used for pin cops. Standard diameter of spindle wharve is $\frac{3}{4}$ inch, but $\frac{5}{8}$ inch if 5-inch tin roller is used.

In calculating twist or spindle revolutions it is best to plus one diameter of spindle band to tin roller and spindle wharve as its effect is much greater on the wharve diameter than on tin roller diameter.

It is better to have $\frac{3}{4}$-inch wharve and lower speeds of rim or counter shaft than to have $\frac{7}{8}$-inch spindle wharve with higher rim

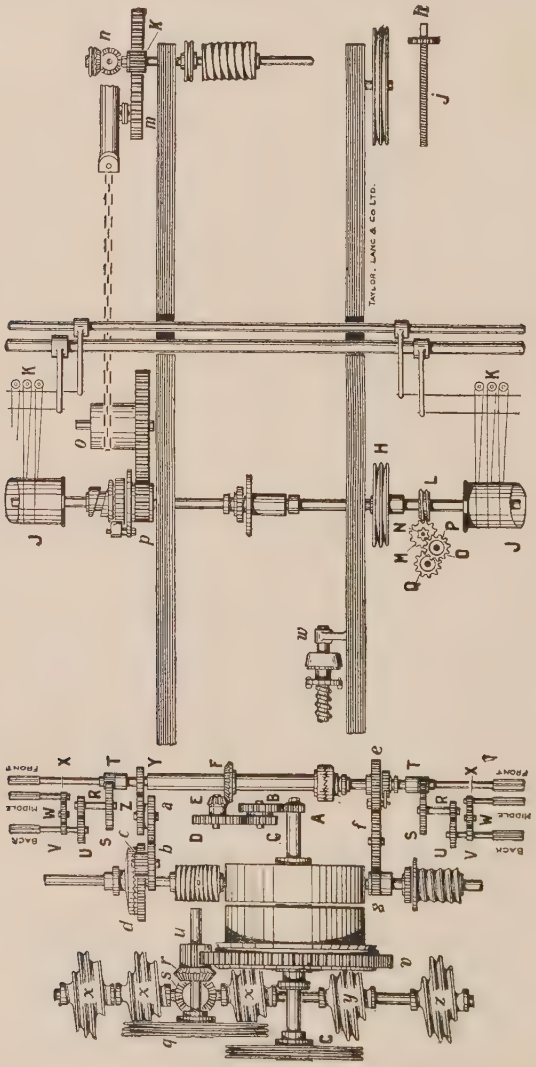


FIG. 108.

speeds. The former rope rim pulley diameters of 20 to 26 inches are now seldom used, 16 inches being better owing to the frequent reversal of direction in backing-off.

Taylor-Lang Mule. References to Diagram (Fig. 108).

A	Rim pinion	20—54
B	Speed wheel	40—80
C	Second speed change wheel	40—80
D	Third speed change wheel	40—80
E	Speed wheel bevel	20 & 24
F	Front spindle bevel	42
G	Rim	7 in.—25 in.
H	Tin roller pulley	9 in.—15 in.
J	Tin roller	6 in.
K	Spindle Wharve	$\frac{5}{8}$ in.—$1\frac{3}{4}$ in.
L	Twist motion worm	Single worm
M	Twist motion worm wheel	50
N	First twist motion wheel	20—30
O	Second twist motion wheel	50—60
P	First twist motion change wheel (under O)	20—30
Q	Second twist motion change wheel	50—60
R	Draft change pinion	15—70
S	Crown wheel	80—140
T	Front spindle pinion	15—22
U	Back roller wheel	30—60
V	Breakage wheel on back roller	14—22
W	Breakage wheel carrier	66
X	Breakage wheel on middle roller	14—22
Y	Cannon pinion driving carriage	24—40
Z	First drag change wheel	40—80

a	Second drag change wheel	40—80
b	Third drag change wheel	40—80
c	Drag pinion	17
d	Back shaft wheel	60
e	Roller motion wheel on front spindle	54
f	Roller motion carrier wheel	70
g	Roller motion pinion on back shaft	17—21
h	Shaper wheel	10—70
j	Shaper screw, per inch	Pitch 2—12
k	Quadrant pinion	12—20
m	Quadrant segment	—
n	Quadrant governor motion bevels	33/48
o	Winding drum and wheel	$5\frac{1}{2}$ in.—7 in dia. 76 & 84, p. ; 63 & 70, p.
p	Winding pinion	16—30, p. ; 16—25, p.
q	Rope taking-in pulley	15 in.—20 in.
r	Taking-in shaft bevel	16 & 18
s	Upright shaft bevel	20 & 21
t	Scroll shaft bevels (not shown)	11/50
u	Backing-off pinion	13
v	Backing-off wheel	93
w	Cam shaft	—
x	Taking-in scrolls	—
y	Check taking-in scroll	—
z	Assistant taking-in scroll	—

Usual Change Places.

Rim pinion (A) — Draft pinion (R)
Speed wheel (B) — Crown wheel (S)
Rim (G)

Drag wheel (a) — Twist wheel (P)
Drag wheel (b) — Twist wheel (Q)
Shaper wheel (h)

Fast and loose pulleys 16 to 18 inches diameter.

Double roving is general for fine and high qualities of yarn, as it gives a more uniform and stronger yarn, although much more expensive. Single roving is common for ordinary American and Indian cotton.

Steady bands, under-carriage bands, and middle drawing-out bands, all help to give steady working of carriage, but a mule will work without them, especially if short and strongly built.

Self-centreing bolsters are in existence if anyone were to require them. One side of the bolster is flattened to keep it from turning. Bolster and spindle automatically adjust themselves.

Various devices are used for gripping the thick check-band and allowing a spare length to lie across the carriage front.

All metal and semi metal carriages are increasing in use. The author is in touch with a mill which is full of them, and they are well liked after sixteen years' use, keeping in square well, working in a straight line, and running lightly. They are much less subject to fire damage than wood carriages, and not affected by oil and atmospheric changes.

Draper's floor stops to check the carriage when fully out or fully in, are used by some spinners. Also his rolling weights for counter fallers. Bastard cops are sometimes spun on pin cop spindles of 14-inch length and the bolsters dropped, but it is better done on spindles 15 or 15½ inches. A twist spindle 17½ inches long may be 8¾ or 9 inches out "abreast," a bastard spindle 15½ inches long may be 7½ inches or 7¾ inches out "abreast," and a 14-inch pin cop spindle 6½ inches out of bolster.

Tube sticks may be had in aluminium or other metal, fitted with two stop-screws to come on the bolster and ensure tubes to be all one height, this being very desirable to obtain good winding and copping. Accurately spaced to the spindle gauge and serving for about a dozen spindles. Rougher specimens are sometimes made at the mills.

Portable tubing magazines apparently increase in use, each serving as many spindles at one release as minder or piecer can conveniently handle, say about two dozen or so. It is desirable for each one to hold sufficient tubes for one half mule, say 550 or so with 1¾-spindle gauge. Piecers may fill the magazines between doffings, and their use facilitates doffing and reduces payment for tubing. A simple movement of a slide brings a fresh row of tubes in position.

Hank rovings. For 6's from Indian cotton, low American or cotton waste, we may use 1¼-hank slubbing or intermediate with bobbins 8 to 9 inches long.

For 16's American, 2½-hank. 26's American, 3¼. 36's American, 4¾. 46's American, 5¼. 60's weft American may take

6 hank single roving. 60's twist Egyptian double roving, 11½ or 12 hank. 80's twist double roving, 14-hank. 100's double roving, combed Egyptian, 17 hank.

Hosiery yarns are frequently spun rather softer than weft but of twist size in cops. Both from American cotton and Egyptian, sometimes double roving Egyptian in low counts to get good yarn of very low twist and therefore very soft.

In self-acting mules, medium counts of yarn one quarter of time or more is lost in backing-off, drawing-up, and changing.

In four draws per minute, one draw equals fifteen seconds, of which four seconds or more may be lost. In five draws per minute the lost proportion would be greater probably.

Jagger & Co.'s Paste Boxes with Regulator, for Cop Bottoms.

The utility of pasting or starching cop bottoms is well known. There are, however, some very great disadvantages which render the

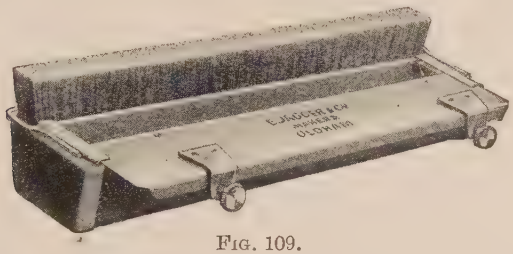


Fig. 109.

use of this valuable property objectionable, and in most cases the objections will be found to arise from the style of paste box and brush used. The flowing of paste over the spindle board, and the making up of the bolster steps (thus giving to the top of the carriage a dirty, unsightly appearance in the one case, and binding fast of the spindles in the other), are looked upon as co-existent with and inseparable from the use of paste. It is clear that where a substance is overflowing to waste there ought to be curtailment, and also, where the same runs short, that which would be wasted should be brought to its assistance. It is important to do the work with cleanliness, evenness of supply to each cop bottom, and for the general efficient accomplishment of the object in view.

This is aided by using the paste box as illustrated in Fig. 109, which will be found handy to use, easy to regulate and re-fill, efficient in its work, durable in wear, and cheap at first cost.

The ordinary box is 10 inches long by 2½ inches wide, and 1¾ inch deep (over all), the back of which slopes outward, forming

an obtuse angle with the bottom, the division inside following the same course to enable the paste or starch to run down the slope to the brush when in use. The regulators at front of lid, or sluice, are of the most simple character, which, by screwing or unscrewing, the sluice or lid can be set to any size of opening for the outlet of paste or starch. These screws, however, do not interfere in the least with the re-filling of the box, as the lid or sluice can be opened, the box filled, and sluice replaced without interfering at all with the adjusting screws. The slides into which the sluice or lid works are so fixed to the flanges at ends as to grip them tightly between, in addition to being soldered, thereby removing the possibility of slides coming off, as in almost all others is the case. The ends are riveted with copper rivets, and well soldered. The material is of extra strong specially rolled sheet brass, with steel wire across back, to strengthen and prevent the wear that would otherwise occur by sliding on the spindle board.

Paste Boxes.

Method of applying starch or paste to cop-bottoms is to run a paste brush quickly along the cop bottoms when four to eight draws of yarn have been wound on after doffing.

The paste must be well boiled and mixed, good enough to guarantee firm cop bottoms from a rapid and self-drying application.

Some minders make one application serve, while others run once backwards and forwards in perhaps three draws of a four draw a minute mule.

At the same time the "big piecer" starches the other half mule.

Compared with tubes, this process is very dirty on the carriages and bolsters, but is done much quicker.

There is more cop bottom waste with pasted bottoms and so pasting is seldom done for fine yarns.

The up-to-date paste box shown in sketch will permit of ready regulation of paste from box to brush and also is convenient for re-filling.

Mule Rollers.

Rim at side headstocks are for very low rooms, with the line shaft running parallel to the roller beam and the counter shafts over the middle of the wheel gate.

To prevent heavily weighted counter fallers from rising during spinning, special locking motions may be applied.

Short top front rollers of fast boss, two threads per roller are customary for fine counts, and are dead weighted. Back and middle top rollers self-weighted.

Three ends per boss or six per top roller, loose boss rollers, lever weighted, are customary for American or Indian cotton.

Four threads per roller sometimes recommended for single roving Egyptian, top rollers either fast or loose boss, lever weighted.

Eight threads per roller or four per boss, have often been used for pin cop weft gauge American cotton.

Long top rollers give fewer roller ends and middles to pick and oil, but are not so sure and accurate in drafting, especially if the roller covering is not of the most level character.

The short top rollers of fine mules, with the small and light middle top roller, self-weighted, enable front and middle top rollers to be set inside the fibre length, without breaking the fibre, this being the best remedy for middle iron roller laps, when a good deal of roller draft is put in. In fast running mules, the mule near the roller beam may depress a lever which applies extra spring pressure to back shaft box for the first few inches of run out.

Treble grooved rim pulleys are more popular than double-grooved, owing to longer life of rim band, and more uniform twist in the yarn, although the treble bands are more difficult to put on again when they fly off, and they also make a mule heavier to drive.

Spindles vary in length from 14 inches for small pin cops, up to 17½ inches for twist, and up to 24 inches for the largest cops in condenser spinning.

Modern Cotton Waste Mule Special Features.

1. Arrangements to give three speeds of spindle; minimum, middle, and maximum during every draw. The large amount of carriage draft requires the low initial spindle speeds and then production requires the maximum.
2. Carriage retarding motion to delay the start of the carriage after the rollers.
3. Slow setting-on motion.
4. Stopping handle under all the fallers.

Details (Special) for Fine Spinning.

1. Deep section roller beam, japanned to show up the threads.
2. Single thread boss rollers, either with fixed or with adjustable cap nebs.
3. Long top clearers aided by about two conical clearers to give a lateral traverse to the others and obtain better cleaning. Used alone for very fine counts.
4. Long fluker rods instead of "crows."
5. Middle roving guides for double roving.
6. Sometimes wire rings in skewer holes to reduce friction.

7. Revolving perforated rollers as top and middle guide rods for rovings.

8. Counter fallers mounted on anti-friction bowls.

9. Counter faller depression levers in middle of each half.

10. Very general use of winding roller delivery motion.

11. Roller delivery during jacking and twisting at the head.

12. Jacking motion for completing last short position of each outward carriage traverse at only one-fourth to one-sixth of spinning speed, with rollers either completely stopped or worked only by "receding" motion as per No. 11.

13. Faller depression motion for bringing winding wire almost to spindle points before backing-off starts.

14. Fine rim or slow turning motion for spindles during faller unlocking.

15. Twist motion either on rim shaft or tin roller shaft.

16. Belt taking-in instead of rope.

17. Single and double speed motion either on rim-shaft or top shafts. Some of these motions are occasionally used for medium counts of yarn. Some are omitted in fine spinning mules.

Stationary Bush for Loose Pulley.

The loose pulley has often been made to run on the rim shaft, and brass bushed to prevent wear of rim shaft. In other cases the loose pulley was run upon the extended boss of the fast pulley.

A more modern arrangement is to mount the loose pulley upon a stationary sleeve which forms an extension of the front rim shaft bearing.

This arrangement removes the loose pulley from affecting either the fast pulley or the rim shaft, and the loose pulley cannot affect the speed of spindles during winding on. It is all the better for the backing off-friction, but the general arrangement of fast pulley, loose pulley, and friction, needs special setting-out.

In the Taylor-Lang mule the stationary bush of cast-iron is lined with brass, and gives a metal to metal bearing for loose pulley as well as a very long bearing for the rim shaft. Special oiling facilities are provided. In duplex driving two bushes are used.

Automatic Nosing Motions.

Nosing motions take the form of a peg or pegs pressing down and deflecting the winding chain, a supplementary chain pulling down at the winding chain, using a scroll winding drum, pushing up at the inside portion of the chain just before the carriage reaches the roller beam, or pulling back at the chain at the quadrant end.

The copping motion is the accepted position for controlling the automatic application of a nosing motion.

While one important firm makes to the taper or scroll winding drum, most other firms prefer to apply automatic motions for deflecting the winding chain, and mostly by means of a nosing depression arm worked from the copping motion connecting rod.

Stopping Handles.

Turn-over motions for stopping the mule close to the back stops, foot levers or hand levers for holding or quickly disengaging the taking-in friction, and levers for quickly moving the down belt on the loose pulley, should always be applied and always kept in good order.

It would probably be better if ordinary spinning mules were fitted with long rods under the fallers, for stopping the mule from any part of the mule, and such arrangements are often applied to condenser mules.

Taper forks for the down belts are sometimes applied to compel the belts to bend always one way when changing pulleys and prevent laces and leading ends of belts from catching the forks.

Parallel strap forks are applied by some firms and are probably best for the belt edges.

Winding Clicks.

Many mules are yet at work in which the winding click is engaged by the actual start in of the mule carriage.

In some cases the sliding of the long back-off rod at disengagement of friction is allowed to gear the click. Other cases exist in which the long connecting rod of the taking-in friction and holding-out catch engages the click as the taking-in friction engages.

Box clutches after the style of roller boxes have been used instead of the ordinary winding catch, but give too much danger of striking fire by teeth catching as the carriage comes out.

Combinations of two, three, or even four clicks or catches have been tried, but have not received much favour.

Cone and cam winding clicks have been very extensively adopted and applied by several firms.

Prompt and regular engagement of the winding catch at every start-in of the mule is aimed at, and tends to give regular winding, with better results in regard to snarls and tight winding.

In the cone winding click, locking of the faller leg is accompanied by withdrawing a cam or a circular cone from beneath a part of the winding click, with the result that a circular flat spring promply engages the click before the carriage starts in. Unlocking of fallers is attended by the cone disengaging the click.

Good results are obtained by careful setting of these click motions, but failure to disengage has often resulted from unskilful adjustment.

Depth of Faller Lock.

Formerly the front and back inclines of the copping rail were all cast in one piece, and no middle plate was used, with the result that faller locking the first draw after doffing might occur at the apex of the piece of cop, and yet later on the depth of faller lock might be so excessive as to break the threads. By depth of faller lock is meant the amount the winding faller wire is taken below the apex of the cop during backing-off, before the fallers are locked into winding-on position. It is advisable to have this depth kept within reasonable limits for all stages of the cop building, and this effect is obtained having a loose front incline, supported by a special copping plate to itself. This plate is very much of the same shape as the back plate, so that the initial and terminal extremes of the rail—representing the beginning and the end of winding-on —are lowered in any ratio desired, and the depth of lock is neither too shallow at the beginning, nor too deep at the full thickness of cop, as was formerly the case. This helps to obtain good cop noses and to distribute the crossing coils or yarn on the cop noses with the net result that somewhat improved unwinding and reduced waste may be obtained if the parts are adjusted and controlled to the best advantage.

Changing Counts.

Mule Calculation.—A mule is spinning 80's twist from 15-hank roving, and has on the following wheels: Front roller wheel, 18 teeth: crown wheel, 140 teeth; change pinion, 44 teeth; back roller wheel, 56 teeth; twist wheel, 75 teeth; back change wheel, 70 teeth; gain wheel, 85 teeth; gain pinion, 52 teeth; shaper, 60 teeth; rim pulley, 19 inches diameter; calculate the wheels necessary for changing to 100's twist.

According to the question the same 15-hank roving is used for both the 80's and the 100's counts.

1. *Change Pinion.*—Assuming all the alteration in counts to be effected by the change pinion, this wheel would be found as follows:—

$$\frac{80 \times 44}{100} = 35{\cdot}2.$$

If this pinion were considered too small a portion of the change might be allocated to the back roller wheel by a simple proportion

calculation. We will assume a 40's change pinion to be put on, and determine the required back roller wheel to work with this larger change wheel,

$$\frac{56 \times 40}{35{\cdot}2} = 63{\cdot}63 \text{ back roller wheel.}$$

2. *Shaper Wheel.*—The square root rule appears to be used by many people, and by this rule the new shaper wheel would be determined as follows :—

$\sqrt{80}$'s : $\sqrt{100}$'s : : 60 : ?

80·00000(8·94 = sq. root of 80's
64 and 10 = sq. root of 100's

169)1600
1521

1784)7900
7136

764

$$\frac{60 \times 10}{8{\cdot}94} = \frac{600}{8{\cdot}94} = 67{\cdot}11 \text{ say } 67 \text{ builder or by sq. root.}$$

Probably in a greater number of cases the simple proportion method is found to do best, and works out as follows :—

$$\frac{60 \times 100}{80} = 75.$$

It is probable that the best practical working rule, and the most generally applicable one is to add the results obtained by the two previous methods and divide by two.

67
75

2)142

71 new builder wheel to be put on,

allowing for the 100's to be wound under a less tension than the 80's.

3. *Gain Pinion.*—There is no definitely fixed rule for calculating the gain wheel in changes of counts. We should probably decide to put in one or two more teeth of gain for the 100's without making a calculation. Suppose, however, that we have on the

85's large or driven gain wheel, and we decide to put $1\frac{1}{4}$ inches more gain for 100's than for 80's. A smaller wheel would put in more drag, and assuming we delivered 59 inches of yarn per stretch for 80's, we now only want to deliver $57\frac{3}{4}$ inches.

$$\frac{57{\cdot}75 \times 85}{59} = 83{\cdot}19 \text{ say put on an 83's gain wheel.}$$

The back change wheel, the twist wheel, and the rim pulley must be considered in relation to each other as each one of these three details has to do directly with the twist per inch. Twist varies usually in direct proportion with the square roots of the counts, so in this case it should vary as—

$$8{\cdot}94 : 10.$$

First we may dispose of the back change wheel, or as it is better known in the Oldham and other districts on lower counts, the speed wheel. It is to be assumed that we shall require the carriage to move out more slowly for the 100's than for the 80's in order to give more piecing-up capacity, and it would probably be found best to reduce the spindle speed by putting on an inch smaller rim pulley in order to give sufficiently good spinning, especially as the same cotton and the same hank roving are being used. This alteration is, of course, an optional one. Without calculation we will assume that it is advisable to come out distinctly slower, although not advisable to obtain all the extra twist in this manner. Approximately splitting the alteration in wheel size required we will put on a 74 back change wheel, so that we now have a calculation as follows: Suppose we are spinning 80's with a 70's back change wheel, 75's twist wheel, and 19-inch rim pulley. We require to spin 100's from same hank roving, and we reduce the rim pulley from 19-inch to 18-inch, and increase back change wheel from 70 to 75, what twist wheel must be put on? We have the statement:—

$$8{\cdot}94 : 10 :: 75 : ?$$
$$\frac{75 \times 10}{8{\cdot}94} = 83{\cdot}89.$$

Twist wheel if the rim pulley had not been altered—

$$18'' : 19'' :: 83{\cdot}39 : ?$$
$$\frac{83{\cdot}89 \times 19}{18} = 88{\cdot}55.$$

Accordingly we should put on either an 88 or 89 twist wheel, as deemed best. With regard to the back change wheel it will be remembered that the larger wheel increases the twist coming out,

but with the same twist wheel kept on we should merely have had proportionately less supplementary twist, and left the final twist per inch unaltered.

Mule Calculation.

How many hanks will be produced by a pair of mules, each mule containing 1,020 spindles, spinning 34's twist, 64-inch stretch, making 4 draws per minute, doffing 9 times per week each mule, $56\frac{1}{2}$ hours per week, allowing $1\frac{1}{2}$ hours for cleaning, 6 minutes allowed each time for doffing, 81 minutes per week allowed for breakages?

Total loss worked out as below:—

90 minutes per mule for cleaning,
81 ,, ,, ,, ,, breakage,
54 ,, ,, ,, ,, doffing,

225 ,, total loss.
$56{\cdot}5 \times 60 = 3390$ minutes per week,
225 ,, loss,

3165 minutes actually working.

Then—

$$\frac{\text{Stretch in.} \times \text{Draws per min.} \times \text{Mins.} \times \text{Spindles per mule.} \times \text{Mules.}}{\text{Hank} \times \text{yds. per hank}} = \frac{64 \times 4 \times 3165 \times 1020 \times 2}{12 \times 3 \times 840} = 54659 \text{ hanks.}$$

Principles and proportions hold good for a week of 48 hours.

Creels.

1. Three heights single for single roving twist $1\frac{3}{8}$-inch gauge.
2. Three heights double for single roving weft $1\frac{1}{8}$-inch gauge, each double row on one bar.
3. Four heights single for double roving twist gauge, bottom row being placed below the top of sampson or spring piece, using full and half bobbins alternately.
4. For double roving pin cops a four height double creel may be used—two rows on one bar.
5. For bobbins of 8 or 9 inches left for preparation yarns $1\frac{3}{4}$ inches or greater spindle gauge, a two height creel may be used, with lower row single and upper row double.
6. Table creels for dark positions, with all bobbins one height, revolving on vertical spindles, are now seldom used. Electric light is convenient for any specially dark positions with ordinary creels.

Automatic Backing-off Chain-Tightening Motions.

These are applied to most mules.

A supplementary or shortening chain is used, and wraps round the snail plate the opposite way from the backing-off chain. The other end of shortening chain is connected to a lever whose lower end enters the line of a bracket or incline coupled to the long connecting rod of the copping plates.

The shortening lever comes against the incline or bracket every time the carriage approaches the holding out catch so that the shortening chain is drawn off the snail and the backing-off chain drawn thereupon. Just after doffing the apex of the cop is a long way from the spindle point and several coils of yarn are round the spindle, so that a slacker chain is needed, than when the cop is nearly built and few coils are round the spindle. With a slack chain in top of set, too much yarn is uncoiled in backing-off and bad cop noses result.

Re-threading the Rim Band.

The treble grooved rim pulley is the favourite because of the longer life of the band and its more uniform twisting, although it is often very troublesome to re-thread if it happens to fly off. In such cases the band sometimes becomes so entangled that the spinner deems it best to cut the band, take it clean off, and entirely re-thread it.

Exact procedure depends somewhat on the make of mule and direction the band runs.

For some mules the following is a good method. Have the mule a good part of the way out and the band nicely and loosely coiled near the front carriage wheel with its tail end fast to some fixing of the carriage square. Thread the first end of band on the outside groove of the upper back carrier pulley, and then round the inside groove of the rim pulley itself. Keep on the inside groove of *all* the other pulleys all round until again reaching the *rim pulley* at which take the centre groove. Now follow all round on the centre grooves until reaching the rim pulley for the third time. The natural thing now will be to cross from middle groove of carrier to outside groove of rim pulley, and thence round until the other or tail end of the rim band is met.

A trial re-threading with spindle banding is sometimes beneficial.

Almost the only formula really necessary to remember is that starting with the top carrier and rim pulley we take outside-inside. Other procedure follows naturally, and the same starting method is suitable for a double groove, and succeeding procedure on similar lines but more simple.

Spinner's Knot.

To tie a *spinner's* scroll band knot, first straighten the three strands on the left hand. Take the second or middle strand right round the left one, and then the third or right-hand strand right round the second or middle strand. Finally take the right-hand strand right round the others and through a loop formed by the finger with the left or first strand. Pull tightly and squarely on all three strands. Every move is from right to left. Three loops or crossings should show at the knot end and pulling at two of the ends should again loosen a knot however tightly pulled, and yet no amount of pull the working way could slip a correct spinner's knot. It is particularly suitable for quick tightening of a band. The modern front fasteners for long scroll bands diminish the need for special methods of putting new ones on, but a new band is sometimes put on with the back end off its scroll for the first part draw to allow for extreme pulling out of the band.

Backing-off by Cam.

The charging or engagement of the backing-off friction by means of a cam operated from the twist motion train of wheels is a subject which has considerably exercised the minds of many practical men. It may be explained that the more usual method is to charge the friction by means of the terminal outward traverse of the carriage, operating through the medium of levers, springs, and a long backing-off rod—a method which has proved wonderfully effective in the vast majority of cases.

It is in the case of fine spinning mules that the need appears to have been felt for a backing-off motion engaged by a method entirely different in principle from the rod, spring, and lever method. Engagement by twisting motion is considered to afford a more uniform timing action between the changing of the down belt upon its loose pulley, and the engagement of the friction. With the twisting motion in action it has not been practicable to utilise the strap-relieving principle fully in order to ease the work of the backing-off friction, and this may have influenced the application of the cam backing-off. Nowadays the strap-relieving principle has become extensively applied to twisting motion mules, to the extent of half-changing the belt, and we are not sure this will not prevent some people from thinking any further about cam backing-off. With the cam method the friction is forced in as powerfully and as certainly as need be, but with a cam making possibly only 1 revolution for about 200 revolutions of the rim shaft.

Size and Shape of Cam.

As regards size it is the amount of throw that requires to be largely considered, and the question of the cam having a clear passage in its rotation. Cases have existed in which the size of cam has been altered, and yet it has been quite easy to keep the backing-off correct owing to the means provided in connection with the long backing-off rods for varying the period of engagement of the rods. The cam rod may have 2 inches movement, but the first inch may be made to count for nothing by not allowing it to move the backing-off rod proper. On the contrary, adjustments may be made so that the two rods have almost equal longitudinal movements. Wrought-iron rods have been preferred in some cases.

There are, however, other things to consider, and cases have been known in which enlarged patterns of cams have compelled various small alterations to provide a clear circular path without the cam touching anything, and without overcharging the cam rod. It is usual to have two acting parts to this cam, one for releasing the belt fork, and the other for gearing the friction. A slot is provided for the belt releasing bowl, so that the release can take place sooner or later relatively to the friction gearing. Assuming this bowl to be set in its most forward position, it is possible the belt might be released before the friction were sufficiently engaged, in which case the mule would not back-off. On the other hand the bowl might be put back in the slot so late that the friction would be geared and fighting against the down belt for mastery of the rim shaft before the belt were released. Obviously the golden mean is required to be determined so that the two actions shall be timed to each other to obtain the best results, and it is only by a little experiment that the exact best position of the bowl may be determined. Binding of some of the parts has before now caused the end of the twist wheel screw to be broken off.

Hand Disengagement of Friction.

One of the advantages of this method of cam backing-off—showing up at times when re-starting after a sawney—is the capacity for readily disengaging the backing-off with backing-off quarter or half completed. It is usual to provide two backing-off rods, the first one being charged directly by the cam, and this first one becoming latched with the second rod just before the carriage gets fully out. Backing-off is usually disengaged by the cam rod being moved clear from the backing-off rod proper at the completion of backing-off and the locking of the fallers. The cam rod is still rigidly held forward by the cam, but being unlatched from the

second rod, the latter is then moved by a spring so as to disengage the friction.

To obtain the best results in the readiest manner with cam backing-off the minder will unlatch the first rod from the second just at the start of backing-off or possibly when backing-off is about one-quarter performed. The unlatching may be done very easily and readily, and is followed promptly by the friction coming out of gear. The minder may now have the rim band turned by hand so as to back-off at any speed required, and this affords a somewhat convenient and effective method of regulating the tension of the threads, and if required odd refractory threads may be adjusted by twisting the spindle by hand. Or he may hold the rod and friction in by hand.

It would be worth while to adopt some little device in connection with the carriage charging method of backing-off so as to give this facility for hand disengaging of the backing-off friction when required. It is quite true that it can already be done with a little trouble, but it wants making more convenient and easy. When the well-known belt crank lever of the ordinary backing-off motion is once charged, it is not a very easy thing to disengage the friction without locking the fallers and to do this in a sufficiently simple and quick manner for satisfying the average minder, and without unscrewing or dislocating any of the parts. All this, however, can be done readily enough on the cam backing-off mule, and yet the mule work on the next draw without any further attention whatever.

Short Draw.

This particular feature also comes in when making a short draw, and the man accustomed only to working American cotton single roving must remember that a good deal more trouble is needed on Egyptian and Sea Islands cotton after a sawney in order to start up with the threads as free as possible from snarls and bad ends. Such defects depreciate combed yarns—and especially in the finer numbers—much more in proportion than the relatively cheaper carded yarns from American cotton reaching, say, about 30's counts. Hence it may well happen that a convenience or mechanical appliance considered of distinct value for the higher priced yarns, may not be deemed worth consideration or application on mules spinning American cotton into coarser yarns. Speaking from personal experience, however, it appears to the writer it would be worth while to consider the application of a hand disengagement device to spring, rod, and shark's jaw mules. Such a device should not involve taking a spring off, nor unloosing a collar or a lever, or the dislocation of any adjustable part, but should simply require some such trivial operation as turning a small lever

over, or unlatching a bracket, rod, or lever by hand, which would otherwise be unlatched automatically if backing-off were allowed to take place as usual.

Re-Setting of Cam Motion.

Dealing with this cam in connection with sawnies, it may be as well to point out that after a short draw the position of the cam should be re-adjusted, or the yarn during the next succeeding draw may receive a wrong proportion of twist per inch. Assuming, for example, that the cam has moved about half-way round when the mule is stopped, and a short draw is made. If left in this position of cam then the next draw, it is probable the cam will make $1\frac{1}{2}$ revolutions before twisting has finished and backing-off occurs. To prevent this before re-starting after the short draw, some part of the mechanism for operating the cam should be taken out of gear—the twist wheel for example—and the cam turned to the position it occupies every ordinary working draw, at the commencement of such draw. In this trifling respect the cam backing-off is very slightly inferior to the shark's jaw method of backing-off. As a rule the acting part of the cam remains more or less pushing against the cam rod until just after the mule has actually started moving outwards, and this, of course, affords an excellent guide for adjusting the position of the cam after a short draw has been made. Cam backing-off finds its chief vogue in spinning the finer and more costly yarns, and these yarns should not be deteriorated by even one draw of yarn nearly double twisted.

Cam Backing-off and Tin Roller Twisting Motions.

Cam backing-off is usually associated with the application of the twisting motion to the rim shaft. There is, however, a growing tendency to apply the twisting motion to the tin roller shaft in order to prevent any variation or loss of twist in the yarn due to slippage of the rim band. The question has been put to the writer, why not develop the principle of cam backing-off, so that it can be worked from the tin roller shaft, either with or without a twisting motion. We may say that we see no reason why such a development should not take place, and we are inclined to think that the mechanism need not be one whit more complicated or costly than using the rim shaft twist motion. Both the tin roller twist motion and the cam backing-off are associated directly with the idea of obtaining exact twist per inch, and easy, uniform backing-off at the right moment. We imagine the lines of the suggested device might conveniently run on something like the following basis. Use the second or long bottom backing-off rod much

the same as at present, but use at the front end of the headstock only a short latch lever for the cam to operate directly against. With the tin roller twisting motion there is always a long strap fork rod reaching towards the headstock front, and the backing-off cam would be compounded with a bowl or other part for acting on this long rod. It is quite possible that one long rod might serve for releasing the belt and charging the friction if proper bell crank levers were connected at the strap and friction end, and if this were done the device would probably secure adoption owing to securing additional advantages from the use of a somewhat reduced amount of mechanism.

Ratching and Receding Motions.

These mechanisms are peculiar to fine spinning mules ranging in counts from 50's to finest counts spun, but occasionally used for lower counts.

A receding motion drives the rollers very slowly indeed during twisting at the head to prevent the supplementary twist from breaking the threads. Sometimes also applied during ratching. An excessive amount of receding would be a $\frac{1}{2}$ inch delivery while putting in $\frac{1}{4}$ of total twist per inch with carriage fully out.

The mechanical principle involved consists usually in having a free wheel drive by catch and catch wheel which is much too slow to act while the roller box is shut but comes into action when that box is opened.

Ratching or jacking, or second stretch, comes into action just prior to the carriage getting fully out, its object being to take out all snarls and draw out any thicker portions of yarn ; ranging from $\frac{3}{8}$-inch to 4 inches per draw. "Ratch" is "gain" intensified.

To prevent the sudden and excessive "drag" from breaking the threads, the carriage is reduced to from one-fourth to one-sixth of full spinning speed, while the rollers are either stopped altogether, or else driven only by the slow receding motion.

Several makers have ratching mechanisms in which the differential motion principle is introduced. Threlfall's use a double carriage box which is changed for ratching to gear in that half which is driven by wheels which are about one-fifth of the speed given by the opposite side.

Dobson & Barlow usually employ a spectacle spring and free wheel system. A spur wheel differential ratching motion has been previously shown for the Taylor-Lang mule.

Messrs. Platt Bros. have long utilised a differential motion between the front roller and back shaft, as described below in their own words and sketch.

When the jacking or stretching motion is used, the cam changes

before the carriage completes its outward run; the jacking motion then draws out the carriage very slowly to the full extent of the draw or stretch. During this time the spindles are revolving at the full speed, and continue to do so until the twist motion finger forces the catch off to allow the strap to go on the loose pulley on the rim-shaft.

This motion is arranged with the back-shaft driving wheel connected to the arm of an epicyclic train of wheels as shown in the illustration fig. 110.

"When the front roller catch box is in gear, the wheel G makes two-thirds of one revolution, whilst the front roller catch box makes one revolution, i.e. two-thirds revolution of arm *a*, and wheel G for one revolution of roller or wheel C. When the catch box

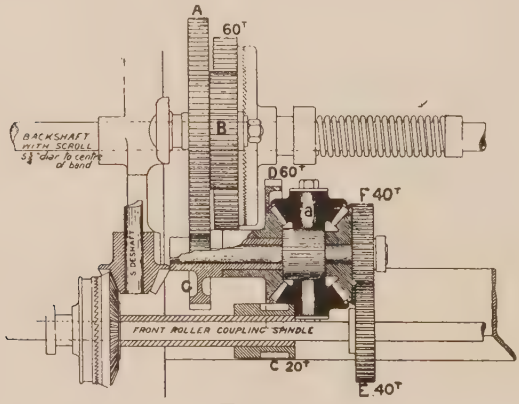


Fig. 110.

is opened, and the front roller stops, then the arm *a* (or wheel G) runs at one-sixth speed of the catch box or wheel C; or in other words, the carriage moves at one-fourth its normal speed."

Backing-off Chain Tightener.

A common method is to attach to the connecting rod of the copping plates an incline which operates when the carriage is nearly out and puts the chain under a sufficient shortening effect. Assuming the faller wire to be one inch above the spindle points just before backing-off, it is argued that a backing-off chain always at one tension and length, does not give quick enough action to the wire at the finish of the set, with consequent soft cop noses, whereas there is too much chance for the wire to catch up with the yarn at the beginning of a set of cops, so that some threads are broken

thereby. The guide pulleys for the backing-off chain should always be centred in such a position that the chain is thrown slack all at once when the fallers lock, or otherwise there will be kicking of the wires.

Carriage Bands.

Referring to the carriage bands Formerly it was a universal practice to have three pairs of these, one at each mule end, and one in the middle of the mule. About 1888 someone started the method of applying an extra pair of carriage bands in the middle of each half mule, and conducting these under the moving carriage to the back shaft. This system came to stop, and soon became very general. The development we now wish to refer to is the gradual tendency towards the supercession of the mule end bands in favour of having all the pairs of drawing-out bands to pass underneath the carriage, the end pairs coming from 2 to 4 feet from the mule ends. By this method we have the manifest advantage of all the pairs of draw-out bands—varying from four to seven pairs per mule —all passing on and off the back shaft, and attached to the carriage at the same angle, so that one pair shall not be pulling against another in any way.

If there is any objection at all to be offered against this little re-arrangement in the carriage bands, it will be in regard to the fact that none of the carriage bands now pull at the carriage anything like so high up as the spindles. The grip of the bands on the carriage is comparatively low down, and there may occasionally be developed a tendency for the spindle points and faller shafts to prove a little dilatory in responding to the pull of the bands on the carriage. In the case of the mule end bands it was quite common for the tightening racks for the bands to be only 6 inches below the spindle bolsters, but in the new arrangement the distance from the bolster rail to the carriage bracket for the draw-out bands is more like 16 inches. This constitutes a disadvantage to the latest method, and it would be better if deeper brackets were bolted to the carriage, and possibly other means adopted for connecting the draw-out bands to a higher position in the carriage. Naturally it is the spindle point that must be primarily considered in anything affecting a question of this kind. The stronger the carriage the better will be the rigidity and the uniformity of action between the top and bottom of the carriage, and metallic carriages are better in this particular respect.

Another feature in favour of the latest method of placing the drawing-out bands is the reduced possibility for short angles and momentary tightening of bands when the carriage is fully in or out. There is no doubt this factor has often adversely affected the working of a back shaft and carriage in cases of mule end carriage bands.

With the new method it is very easy to have back carrier pulleys placed loosely on long studs and capable of sliding along the stud and always keeping the cord in a straight line.

Squaring a Mule Carriage.

Mule carriages are drawn in and out by bands which are affected by wear and tear, temperature, and general working conditions. Always avoid having drawing-out carriage bands of different diameters on the same mule, and see the bands are of correct diameter for the back shaft scrolls that are used. Give due attention to the under carriage bands, and the steady bands, as well as the ordinary out bands. In cases of extreme variation note if any of the back shaft scrolls have slipped on the key or the key slipped round the shaft. In a particular instance the long top end bands always went extremely tight when the carriage got fully out, and it was impossible to work with the back shaft inclines in correct position. Finally it was found that the key of the middle drawing-out scroll in the headstock had been pulled somewhat round the shaft, owing to the long lever and cam shaft having missed changing.

Some minders prefer to square the carriage on the outward run and others on the inward run. Some minders finish off their squaring with the carriage working.

Squaring up may simply mean testing for distance of spindle points from rollers and just slackening or tightening the bands at one or other place. A mule alighting in badly, with slack threads at one position and tight at another, and possibly broken threads, is one criterion of a mule out of square.

One method of more thoroughly squaring the carriage is somewhat as follows:—

Stop the carriage at anything from 1 foot to 3 feet away from the roller beam, and see that the back shaft box is put out of gear. Slacken all the back shaft carriage bands except those at the headstock. All the better if it has been previously noted that these have the scroll incline correct when out at the head, and according to the amount of "knocking-out tight" or slack that is desired. This is more necessary in fine counts as coarser counts from American cotton are frequently spun without any back shaft incline being used.

To put in square we may now pull the carriage in line by the under carriage bands, carefully measuring spindle point to front of rollers. Afterwards gradually tighten up every pair of carriage bands, keeping a strict eye upon the true lining-up. To knock-out tighter, stop the mule part way out, slacken short bands and tighten long ones so as to use a smaller amount of back shaft incline.

In fine mules there is a close connection between knocking-out

tighter by the back shaft inclines, and using more of the jacking or ratching motion to take snarls out.

Both tighten the threads the last short portion of coming out only, whereas "gain" of carriage tensions the threads during all the time of drawing out.

Slack knocking-out means danger of snarls and yarn wrapping somewhat coarser, while if too tight the threads may be pulled down. After squaring a long carriage, some minders will set out a tooth or two at the carriage ends. Correct setting of the back stops is advisable in order to get a mule carriage to drop in squarely and solidly.

In coarse counts the "strap relieving motion" should be used to help bring the carriage nicely to a stand-still on the catch, instead of depending upon using the back shaft incline.

A very tight short band at the headstock may possibly affect the opening of the back shaft box, but there has often been trouble in maintaining a nice working tension on this band.

Seven Points Connected with Winding.

1. The quadrant.
2. The nosing motion.
3. Relation of winding drum and wheels to the quadrant.
4. Copping rail and plates.
5. Drawing-up scrolls.
6. Counter faller.
7. Spindle bevel.

The question is asked: Where is the quadrant arm to be placed when the spindles are running at their slowest speed, to the proportion of the speed to the inward run of the carriage, and also to the thickness of the cop desired? The quadrant arm which carries the slide nut for connecting the winding chain is at right angles to the chain that has been wound off the winding drum. The carriage must have got half-way through its inward run, and the spindles at this point are running at their slowest relative speed and don't much vary for 2 inches or so around this position.

The centre of the axis of the quadrant and the centre of the drum shaft should be as near level as convenient if the best results are to be obtained.

This is for the usual modern method of drawing the chain from the top of the drum.

If unwinding occurred from under side of drum then different centrings would be used.

It is important to adopt a correct relation between diameter of winding drum, relative sizes of winding wheels, and diameters of spindles so that the first draw for bare spindles should have the yarn just nicely taken up with quadrant nut in correct low position.

CHAPTER IX.

TYPICAL MACHINERY EXPERIENCES.

Opener. — After students had been working the opener at the Bolton Technical School and putting waste through it, the machine refused to either feed or deliver cotton properly.

Both defects were traced to lumps of soft waste. At the hopper feed the lifting spiked lattice was scotched by a lump of waste jamming between the lattice and one of the cross-pieces.

At the delivery end both cage shafts were working, but after the upper cage had been lifted out it was found that the lower cage had all its set screws loose so that the shaft revolved but not the cage itself. Waste had got fast and resisted the revolution of the cage.

Certain machine makers put in opening machinery coupled in the component parts as follows :—

In mixing room there was an automatic hopper feed coupled to porcupine opener and from the latter the cotton passed to room below, and over a dirt lattice in dust trunk and thence to Crighton opener, exhaust cylinder, and three-bladed beater before being made into a lap.

With this arrangement the mill people were constantly being troubled by the cotton choking in dust trunk.

The laths on dirt lattice in exhaust feed trunk were reversed, but this did nothing but decrease efficiency of lattice.

It was remedied eventually by the common-sense method of coupling the dust trunk and exhaust cylinder instead of to Crighton.

The order of the passage of the cotton was :—

Before altering.	*After altering.*
1. Hopper feed.	1. Hopper feed.
2. Porcupine opener.	2. Porcupine opener.
3. Dust trunk.	3. Crighton „
4. Crighton opener.	4. Dust trunk.
5. Exhaust cylinder.	5. Exhaust cylinder.
6. Three-bladed beater.	6. Three-bladed beater.

This was for American cotton. The narrow exhaust porcupine sometimes gave stringy cotton on good Egyptian, and one firm are now aiming to dispense with it.

Carding Engines (*a*).—A card was producing a sliver very thin in places, and yet the lap was all correct. Finally it was found that the side shaft change bevel was imperfectly geared with the large feed roller wheel and occasionally slipped a few teeth.

(*b*) On a certain card a cloudy web could not be cured by any of the ordinary settings and remedies. Flats, doffer, and licker-in were all found to be correctly adjusted. Finally, the fault was proved to be due to the feed roller being set too far from its nipping point on the feed plate.

Less Drafting.—A tendency to weakness and irregularity in a certain quality of very good cotton was overcome by re-arranging the draw-frames from eight ends up at each box to six ends and six of a draft at first box, seven ends up and seven of a draft at second box, and eight ends up and eight of a draft at the final box. It was argued that eight of a draft for the well-known irregular sliver produced on a Heilmann comber was excessive and the above system was devised to overcome this and yet obtain the maximum doublings advisable.

Less Beating. –Another quality of Egyptian gained in strength through cutting out the Crighton opener. This may not be so much as an argument against the Crighton, the same result would probably have been obtained through cutting out any other beater, what did cause surprise was a distinct improvement as regards nep.

Curious Bobbin Formation. — An unusual bobbin formation came under notice recently. It had a concave cone at one end and convex at the other. Investigation finally discovered the poker bar to be distinctly bowed in shape, naturally the arc of the poker bar was transmitted to the cone of the bobbin.

The question arises, how did a cast-iron bar, turned in a lathe and having passed through a tooth-cutting machine, assume its novel and inconvenient form, also how did it manage to work?

Fly-Frames.

(*a*) At a mill in Russia an English manager found six intermediate frames, each 144 spindles long, supplying 14 rovers of 184 spindles each.

There was great difficulty in getting off the requisite production from the intermediate frames, and yet the spindle speed had been increased to 890 r.p.m. and a twist wheel of forty-two teeth. There was excessive breakage of ends, and frequent stoppage of frame to piece up due to the high speed.

The new manager reduced the spindle speed to 775 and increased the twist wheel to forty-four teeth.

Result :—

Much better running of frames.

Greatly reduced work for tenters.

Less power to drive the frames.

Greatly increased production owing to much more continuous running of frames although the speeds were lower.

Each pair of intermediates began to serve five rovers, or a total of fifteen instead of fourteen previously.

(*b*) At a Farnworth mill on Egyptian cotton all series of fly-frames were reduced in spindle speed, also in twist per inch, and immediately there was better work and greater production.

(*c*) In the case at (*a*) there were three slubbers supplying the six intermediates, and the slubbers had a spindle speed of 750 revolutions, which was now reduced to 620, the twist wheel being also increased from 50 to 53. There was much better work, easier driving, and increased production.

(*a*) *Slub Yarns.*—Slub yarns were being produced on a self-acting mule from Egyptian cotton 8-hank double roving. Very unsatisfactory results were obtained owing to some rollers often delivering long lengths of undrafted roving after the slub had been produced. The ordinary drafting was often dilatory at re-asserting itself.

An absolute cure was finally effected by using a soft-twisted 4-hank single roving instead of the 8-hank double, since the soft-twisted 4-hank single responded readily to the frequent alteration in drafting effect required to produce the slub yarn.

(*b*) *Snarling Motion.*—On certain mules spinning Egyptian yarns there was often trouble due to snarls obviously made at start out of carriage from roller beam. In this case the internal disc of the roller box contained four slots of varying width, and it was found that the smallest one was in use. By changing to a larger slot an absolute remedy was provided.

(*c*) *Stud for Loose Incline of Copping Rail of Mule.*—On a certain make of mule very bad cop noses were being produced and unsatisfactory winding. Finally it was found the loose incline had been lifted and the front square block or die had fallen into a false position. The defect was promptly remedied by putting the die or stud in correct position.

Spinning.

1. A mule carriage was getting to the stops in an unsatisfactory way, not getting in anything like it should have done and causing a lot of broken yarn. Minder told to square his carriage but no difference made.

Upon examination it was found that his drawing-up scrolls were in a wrong position.

The drawing-up bands were slackened sixteen teeth, the back shaft band shortened, and the check band tightened. This remedied the letting-in of the carriage and made the spinning alright.

The scroll had got out of their proper working position through the minder putting new bands on, and not seeing that the scroll shaft was kept in the right place when tightening them.

2. On a certain mule the cop started giving very thin in diameter after the formation of the cop bottom, and the chase went very long.

It was found that the bowl upon which the fallers lock was loose, and with the pressure placed upon it during winding it kept forcing it farther down the vertical slot in the trail lever and so causing the cop chase to be longer. After setting the bowl, the shaper had to be worked back so as to make the cop something like .

3. A mule was making a very ridgy cop all the way through the set, showing up most at the turn of the cop bottom. This was remedied as follows :—

The copping rail was found to have side play, both on the steady bracket and on the plates. This was made right by altering the steady bracket and making the rail solid on the plates and the ridges in the cop were taken out.

4. In another case of ridgy cop, the rail and plate were perfect for working, but the carriage bowls on the big slips at either side of the headstock were found to have uneven weight on, and also they were not running true on the face of the slip. These bowls were adjusted by the setting screws on the carriage arms, and the ridges disappeared.

5. A mule, after being re-set, worked and wound alright, but during the building of the cop a lump formed in the cop nose; it was noticeable during the formation of the cop bottom, but when getting in the upper part of the cop it became worse, and when ready for doffing it was very bad and the nose and chase were very soft and spongy, particularly on the long side of the mule. Several remedies were tried without success. Finally the broad slip on the long side was taken out and planed up, and the lump disappeared. This slip was found to be hollow in several places when a long straight edge was put on it.

6. It was found necessary to alter the depressing motion in a Dobson mule. There were three motions in, and these were being replaced with two, one in the middle of each side and put an extra salmon head lever on. By adopting this method yet more uniform depressing was obtained. In this case the minder had more broken and cut yarn in the three-end quarters of the long side, and after

spinning a set the fault was looked for. The fallers were working alright, but the carriage could not be kept square in the three-end quarters and with the back shaft's scroll being covered in by the guard, the band could not be seen in the scroll. Upon examination, it was found that the long squaring band was breaking. A new band was put on, and both the faults were remedied.

7. On a Platt's mule the threads kept showing a slackness in different parts of the mule and at irregular intervals, this causing snarls to appear on the cop, appearing as if the tin roller middle piece was loose, but it was not so. The quadrant was altered without effect, the end tightened, but the slackness still appeared. Finally all the chains belonging to the salmon head lever of the fallar were slackened off and all readjusted to one tension, and the defect was remedied.

8. The cam shaft on a Platt mule was found to be changing very irregularly, causing the yarn to be strained and cut. It was found that the key in the cam shaft upon which the cam friction works was loose in the key-way and also the key and key-way badly worn, this allowing the slippage between the friction and the cone wheel. A new cam shaft was put in and the fault remedied.

9. A mule was noticed to be winding very irregularly, the under faller, being pulled lower than it was necessary, caused broken yarn. This was caused by one of the straps biting on the first pulley of the rim shaft during the run-in of the carriage. This often takes place with duplex driving, when one of the straps is replaced and not both, on account of not being able to adjust the strap guider and both straps.

10. In another case of bad winding, it was noticed that the front roller made one revolution, some draws during the run-in, and none during other run-in, this causing the under faller to vary in height. This being a Platt mule, it was found that the plate which carries the stud containing the catch on the back shaft was loose, causing the spring and catch not to engage regularly with the catch wheel on the back shaft. The front roller was not turned regularly. When the plate was screwed up the fault was remedied.

(*d*) *Mules.*—A certain mule was changed from ordinary twist cops of $1\frac{1}{4}$ inch diameter, to spin 6's counts, every other spindle, cops $1\frac{3}{4}$ inch diameter.

The winding could not be got satisfactory when the full cop diameter had been reached, even though the quadrant was set as far back as possible and the quadrant nut was worked as high up as possible. Finally a pair of $\frac{1}{4}$-inch circular shells were prepared, and neatly fastened round the quadrant drum, so as to increase its diameter by $\frac{1}{5}$ inch. Afterwards the winding was quite satisfactory, and the shells could be removed when ordinary cops were required again.

The Opening of the Roller Box on the Self-Actor Mule.

The best method of opening and shutting the roller box of a self-acting mule has frequently engaged the attention of inventors and practical men concerned with the making and working of these machines. The problem becomes a good deal more complicated in the case of fine spinning mules in which there are special motions for turning the rollers during supplementary twisting and inward run of carriage, as well as jacking motions for giving a terminal slow speed to the carriage. In a Platt's mule, for example, the roller box is opened by a short lever from the cam shaft placed almost directly above the roller box, while in an Asa Lees' mule it is opened by a short lever reaching almost directly beneath the roller box. The addition of a jacking motion to the Platt's mule compels the cam shaft to be opened before the carriage gets fully out, although the back shaft must not be opened until the very limit of this traverse. There is thus required a heavy weight and an extra lever in the carriage gear connections, so as to form a supplementary arrangement by which the back shaft box is prevented from opening when the cam shaft makes its first half revolution, but is promptly opened at the absolute termination of the outward carriage traverse. Some other mules are operated without using a cam shaft at all, and the roller box is opened and closed by means of combinations of rods, levers, weights, and springs. Under this general category come such makes of mule as Threlfall's, Dobson's, Howard & Bullough's, and the Curtis mule of Messrs. Hetherington. In one or two cases the movement of the quadrant has been utilised to put under proper tension the springs connected with the movement of the roller box rod. If all mules were fitted with jacking motions it is possible there would be a still greater extension of the principle of opening and shutting the roller box by rods, levers, and springs operated without connection with any central organ, such as long lever or cam shaft, as there is then some advantage in having this box fitted with its own independent changing gear.

Messrs. Dobson & Barlow, for example, have devoted considerable attention to the problem of opening and shutting the roller box, and have during the last three or four years equipped a large number of mules with what is known as Farnworth's motion. With the older arrangement there was occasionally developed a certain tendency for the long rod or one of the two levers concerned, to lock or bind a little, and somewhat interfere with the free and easy opening of the roller box, a defect, however, which could generally be eliminated with skilful adjustment. In Farnworth's motion this tendency is definitely overcome by placing upon the carriage or middle piece only the duty of unlatching a lever which

latches the long rod and the roller box in active gear as the carriage moves out. Immediately the unlatching occurs a strong spring which encircles the rod at once opens the box in one instantaneous, definite action, thus ensuring a uniform ratching or jacking action on the yarn. When the carriage alights at the roller beam the rod is moved back again, and the spring placed under tension until re-latching occurs. The value of this new arrangement is enhanced by the cross lever and other connections being placed behind the roller beam instead of in front thereof. There is no doubt that this change gear for the roller box is well designed and strongly made, and that it embodies some very excellent ideas and principles.

Belt Driving.

Despite the recent advances in individual direct motor driving to the machines in textile mills, belting still fills a foremost position in this respect, from line or counter shaft to machine.

Belts used for driving the machines in woollen, worsted, and cotton mills are almost more exacting than in any other industry, so important is it that accurate, steady, uninterrupted driving shall prevail.

Woven belting of one kind or another has taken the place of leather in many mills for many of the machines, being usually cheaper than leather and obtainable in long lengths of any width desired. Recently a belt maker informed the author they always put on one side, for mule driving, the best leather they could get.

It is the writer's experience that a good leather belt is generally the best of all when real tests and strict experiences are met with. For example, in the case of gallows pulley driving for frames, the writer has known leather to drive beautifully when woven belting quite failed to stick properly on the pulleys, some of the woven belting gets very boardy and stiff at times.

It is the writer's experience that the most permanent and most convenient method of maintaining a leather belt up to maximum efficiency and durability in a cotton mill is to treat it from the back with commercial castor oil, with an occasional small lick on the working surface.

There are excellent preparations available for those who desire the same, such, for instance, as the "cling-surface" of Messrs. Bishop. The chief requirement in belt driving, is to enhance the belt grip on the pulleys, while keeping the belt tension within reasonable limits, and having due regard to the life of the belt and freedom from breakage, or too frequent renewal of the fasteners.

Roller Settings.

When we change a mule to spin 10's instead of 40's—a rather extreme but not unknown change by any means—we are producing yarns which are four times as heavy per yard as for the 40's. Can we wonder if differences of 400 per cent. in weight of cotton dealt with should affect settings and diameters of rollers. An extreme but yet possible case is taken to make the point clearer.

Weightings, settings, diameters, driving, and draftings of rollers must infallibly be much affected under such extreme conditions. Ordinary draft rollers are very adaptable to varying conditions. For thicker material and same fibre length between the rollers it is a general principle that the work would be all the better for heavier weights, wider settings, and shorter drafts; roller diameters can scarcely be altered. With all three lines of rollers saddled together with one lever weight the short ends of the little saddle should all be kept one way.

The general rule with lever weighting of mule rollers and all three lines saddled together, is to have biting points of front and middle rollers $\frac{1}{32}$ to $\frac{1}{16}$ inch greater distance apart than the mean length of fibre. Obviously, many fibres will be less than this, and some will be longer, and no test is better than opening or closing a few rollers and noting the various effects produced.

To work long staple or mixed staple cotton on lever weighted rollers the best plan is to omit the little saddle entirely and have small additions cast on the back ends of big saddles.

Greater resistance is required to overcome a specified force at a high velocity than a much greater force at a low velocity on the same principle as a worm wheel drive.

A spindle band will sustain a considerable weight steadily applied, but will snap readily under same weight suddenly applied.

Slow roller speeds in the same way are better for roller drafting without breaking the cotton fibres.

Each principal fibre in the textile trades, in regular trade use, has a system of numbering differing more or less from the others, and in some cases there are even different systems for the same class of fibre.

These remarks apply to wool, cotton, silk, flax, jute, artificial silk, etc. There are fixed length systems wherein higher numbers indicate thicker yarns; also fixed weight systems wherein higher numbers indicate thinner or fewer yarns.

Sometimes there are mixings of these by doubling and twisting together, and the counts question then involves a knowledge and application of the different systems and denominations employed.

Oil and other Stains.

Stains in yarn and cloth may prove exceedingly troublesome in later processes and appear to be always with us more or less.

Frequent examples of such trouble have arisen. In a specific example coming under the direct notice of the present writer, a bleacher brought some cloth containing slight oil stains running across the cloth in a slanting direction, and similar examples had given infinite trouble.

The defect was finally proved to be due to slight drops of oil getting on the hairpins or needles of the stop-motion at the warping frame, and picking across from one needle and warp thread to another.

In a second example it was found that oil stains originated at the slasher sizer, but great difficulty was experienced in finding the cause. Partly for the sake of economy the sizing becks were heated by live steam which was used for driving the small adjacent engine. Ultimately it was found that drops of cylinder oil often passed along with the used live steam into the sizing beck.

Air Purification.

Air plays a great part in industry. It has been long recognised that many diseases are conveyed on minute solid bodies which are blown about in the atmosphere and which ultimately find their way into our lungs. But it is not so generally recognised that apart from disease microbes there are many other impurities which have a clogging effect upon human vitality and so reduce the output of the human worker, whether brain or manual. We all know from bitter experience that we do not feel our best, and hence do no do our best work, when we are in the midst of a bad fog. On the other hand, almost every one can remember days spent by the seaside when one's whole system was enlivened.

These impurities are mainly of two kinds, gaseous and solid. These are developed and added to the atmosphere of industrial regions at a very high rate. Much thought has been given to the subject of prevention or reduction of such by means of smoke abatement, and so on, but meanwhile something should be done to clear the air of such impurities. Nature's method is simple enough. Rain and wind together scrub the atmosphere and clear the air of all solid and most gaseous impurities. To a very considerable extent the atmosphere is also cleaned by the washing effect of the air being blown across wide expanses of water—the oceans and inland lakes. But in our closely confined industrial areas this action is very limited, because even in districts where there are heavy rainfalls these are not constant enough to keep up with the

development of the impurities. Also it often happens that the impurities are developed under shelter, in workrooms, etc.

Many efforts have been made in the past to continue in a controlled manner nature's method of cleaning the atmosphere. Such efforts have generally consisted in washing the air before it enters the workroom, and afterwards exhausting the vitiated air by means of fans or otherwise. Efforts have been made to purify the air within a building, and cotton mills have not been overlooked in this respect.

PART II.

CHAPTER X.

TESTING.

Testing of Cotton and Cotton Yarns.

Testing in a spinning mill may mean a good deal more than yarn testing alone, although yarn testing for one purpose or another is perhaps done more than any other testing, since yarn represents the finished product of the spinning mill, and becomes the one basis of testing as between producer, agent, and user of the yarn.

(*a*) First of all there is the greatly important testing and judging of the raw cotton from samples, examining the same, and pulling it for length and strength between fingers and thumbs. Immense weights and values of cotton are bought and sold on the judgments formed by such rapid testings.

(*b*) Frequently samples of possibly 100 lb. weight of cotton are carefully passed through the blow-room machinery and carding engines, chiefly in order to test for loss in regard to extraneous matter, short fibre, and invisible loss.

(*c*) In cases of greater importance and greater doubt samples are passed right through the mill, and made into yarn, thus enabling the management to test and judge in regard to working abilities of the cotton, loss due to various factors, strength, colour, and general quality of produced yarn. This may be regarded as the supreme test short of actually following the yarn to the loom, knitting machine, doubling machine, or other subsequent process. Cotton fibre sorting appliances for office use are gaining in favour.

Wide View of Testing.

Testing in a wider sense may mean much more than yarn testing.

It may, for example, mean also testing or examination of coal, oil, sizing materials, materials for cop bottom paste, banding, and testing of mill supplies and accessories generally.

Yarn Testing.

Testing to many persons relates only to yarns, and these may be tested for strength, stretch, or elongation to breaking-point, counts, uniformity, twist, cleanliness, diameter, and moisture.

In making yarn tests a good deal depends upon the make up of the yarn, as to whether it is placed in hank or bundle form. Ball, beam, or chain warp, mule cop, ring bobbin, flanged warper's bobbin, cone or cylindrical cheese from the winding frame.

In many cases yarn must be tested in small pieces pulled out of cloth, and such yarns may be either sized, mercerised, or dyed; the counts of yarn are affected by these features, and sometimes also the strength.

Counts.

Commercial yarns of about 46's sometimes show a variation of two or three counts below and above, although the average may be nearly correct. This may be taken as a basis or typical example of practice.

Care should be taken to have suitable and uniform tension at the wrap reel, and we recommend a speed of twenty-two seconds to wrap one lea per cop, uniform turning.

In Counts Testing. — Uniform tensioning, measuring, and stopping devices are not common in spinning or weaving mills, but more could be done in this respect for testing rooms anywhere.

A lea of yarn stretched out represents ¾ yard or 27 inches, and this may be tested by suspending the lea from an upper fixed hook, passing it under a lower hook, which is weighted to stretch the yarn down and show its length on an indicator scale.

The wrap reel of 1½ yards or 54 inches circumference is in general use in England.

Made for different numbers of cops, mostly for four but often for six. Creel adapted either for mule cops on spindles or for ring-frame bobbins on wood or other kind of pegs.

A common arrangement has brass connecting rods stave to stave for strengthening purposes, a three-bevel wheel drive so that one revolution of handle gives two revolutions to the reel, a clock face to indicate yards, a bell to ring for each lea, a traverse motion to spread the yarn along the reel—some kind of yarn tension rod. Glass hooks for yarn.

About twenty-two seconds may be taken to wrap a lea. The leas may be weighed separately or four leas weighed together. Reference then made to tables of weights and counts made out in grains. Or alternative methods may be used, such as the quadrant counts tester, or the Knowles yarn balance.

Wrapping possibly twice or thrice per week.

Reel started with indicator finger exactly on 120 and preferably with handle at bottom; wrapping finished with handle in same exact position. The handle turns 40, the reel 80 times to wrap from each cop 120 yards or 80 threads, and some testers count 40 of handle to check ringing of bell and pointing of finger. Reel to be turned at a uniform smooth speed and yarn at only customary tension. Better the traverse length and less will be the overlapping of yarn.

Break the finishing end off level with starting end. For weft there is often no strength test required, but for twist or warp a strength test is often wanted, and the two ends of yarn for this may be twisted together. Sometimes for exact strength testing the starting and finishing ends are tied together.

To judge whether reeling tension has been correct the lea may be stretched out and should have an inside measurement of 27 inches.

Oil Stains.

Ignorance and inattention are doubtless responsible for many oil stains, as well as the careless use of oil cans.

Sometimes the mill people have required the use of stainless oils which only leave stains that can be definitely removed by the scouring processes of bleaching and dyeing concerns.

Cloth stains may be due to oil more or less spread out over a portion of the cloth, or due to finishing processes, or to metal-laden particles of oil from the picker spindles at the loom.

There are animal and vegetable oils which are dropped on white cloths, and produce only a colourless spot, removable by saponification.

Also so-called stainless mineral oils which at first only produce a colourless stain, which later may show colour to some extent.

Ordinary mineral oils produce yellowish stains.

Cloth stains may be due to careless use of oil, using unsuitable oil, the wearing or contact of metal with yarn or cloth, or the scouring and bleaching processes not being sufficiently thorough.

Changing of Counts.

Different methods are adopted by different firms for ordering, effecting, and recording changes in counts at fly-frames, mules, and ring frames.

In a large fine spinning mill visited by the writer very recently, the "inside manager" showed in his office a specially prepared board containing a card for each pair of mules, face outwards, containing particulars in regard to counts, draft, twist, gain, and wheels. A fresh ticket was made out for this board whenever the

particulars were altered. For alterations an equivalent ticket was sent to the overlooker and spinner stating alterations now required, such as the following :—

64's combed twist. Hank roving 11½. Back change wheel 82. Gain wheel 78. Draft wheels C.P. 48/70 B.R.W. Shaper wheel 40. Rim pulley 16 inches (as before). Brown tubes 1¼ inch. Until fresh orders. Signed by X.Y.Z.

After a time all wheels and counts should practically become standardised, and tabulated for different counts on different machines, until some special circumstance compels re-arrangement.

Especially in the card-rooms particulars are sometimes prepared in large figures and posted for boards so that anyone may peruse them, thus affording a double guard against error, as well as more than satisfying the requirements of the particular Inspectors. Wages indicators must be clearly stamped on the outside cases in regard to wheels, diameters, or other items affecting productions and wages.

Cotton Yarn.

A former student of the present writer's made a passing call to inquire how the cotton yarn was spun for weaving purposes about 1810, since this student's great-grandfather had started a weaving concern so far back as about 1812 in the Farnworth district. There can be no doubt that yarn at that time could be obtained either from the hand-mule of Crompton or the spinning frame of Arkwright, which had both been thoroughly established and considerably improved in detail. In 1810 cotton spinning upon the factory system was successfully proceeding in different parts of the country. Hargreaves' jenny was devised in 1767, Arkwright's spinning frame patented in 1769, followed by Crompton's mule in 1779. Only a comparatively few years elapsed before both Crompton's and Arkwright's machines were successful, and largely adopted, so that in 1812, the industry of cotton spinning on the factory system had assumed very important dimensions. It has been computed that fifty years after Arkwright's spinning frame was patented, or in 1810, more than one million of the inhabitants of England were directly or indirectly employed in the cotton trade.

The Term "Water-twist."

On various occasions the present writer has been asked in person, by telephone, or by letter, "What is the meaning of water-twist yarn?" Possibly the following explanation may help to an understanding of the origin of this term. It is recorded that Arkwright's first mill was erected about 1770, at Nottingham, and was driven by horses, but expense of working, and various incon-

veniences soon proved this method to be very unsuitable, so that a year or two later a mill was erected at Cromford, in Derbyshire, and was driven by water-power. Afterwards Cromford was the chief place of residence for Arkwright during the remainder of his life, although both previously and subsequently he did a great deal of travelling about the country.

These spinning machines in the Cromford mill were the first to be driven by water-power, and the regularity of the turning affected the quality of the yarn. As a result these frames were termed water spinning frames, and since the yarn soon became noted for its smoothness and strength, it shortly obtained the name of "water-twist."

Previous to the invention of Arkwright's spinning frame it was common to use linen yarn for warps and cotton for wefts. The term "water-twist" has never been quite lost in business transactions, and crops up even at the present time, being apparently applied to yarns spun on the flyer throstle, or to exceptionally strong yarns spun upon the ring frame. It is noteworthy that "water-twist" yarn 100 years ago was extensively used as warp yarn because of its strength, while yarns spun upon the "jenny" or upon the hand-mule were used largely for wefts because of their ability to impart a soft full feeling and appearance to the cloth. After the lapse of a century we are still in much the same position as regards ring frame yarn for warps and yarn from the self-actor mule as wefts.

Mule Twist Wheel Calculation.

From the following details of the gearing of a mule find (1) the size of the twist wheel to give 31·25 turns per inch, and (2) the size of the back change wheel to insert 80 per cent. of the twist during the outward movement of the carriage. A pinion of 21 teeth on the rim shaft drives through a carrier the back change wheel on the side shaft. On the opposite end of this shaft is a bevel wheel of 15 teeth driving another of 26 teeth on the front roller clutch box. A wheel of 30 teeth on the front roller spindle drives through a carrier the gain wheel of 80 teeth, compounded with which is the gain pinion of 48 teeth driving the back shaft clutch box wheel of 97 teeth. The rim pulley on rim shaft is 20 inches diameter, and drives a pulley of 11-inch diameter on the tin roller shaft, on which is a single worm driving a worm wheel of 45 teeth, carried by a vertical stud. On the upper end of this stud is a pinion of 15 teeth driving the twist wheel. The twist wheel releases the twist latch lever every revolution, thus making one revolution per stretch. The tin roller is 6-inch diameter, the spindle

wharves $\frac{3}{4}$-inch diameter, the back shaft scrolls $5\frac{3}{4}$-inch diameter, and the stretch 63 inches.

1. In finding the twist wheel we will first state the general formula which underlies the working of such questions, viz. :—

Revolutions of spindle for one of tin roller × revolutions of tin roller per stretch equals—

Twist per inch × length of stretch.

Understanding this statement fully will enable the required twist wheel to be determined from an equation which can be stated from the particulars supplied.

(*a*) 35·25 twist per inch × 63-inch stretch = 1968·75 = revolutions of spindle per stretch.

(*b*) It follows from above particulars that revolutions of spindle for one of tin roller =

$$\frac{6 \times 4}{3} = 8$$

and since the twist wheel makes 1 r.p.s. we get—

$$\frac{1 \times \text{T.W.} \times 45}{15 \times 1} = \text{revolutions of tin roller per stretch.}$$

$$\therefore \frac{1968{\cdot}75 \times 15 \times 1}{8 \times 45} = 82{\cdot}03 \text{ first answer twist wheel.}$$

N.B.—The equation above referred to, reduced to the actual figures, is as sited below—

$$1968{\cdot}75 = \left(\frac{8 \times 45}{15}\right) \times \text{twist wheel.}$$

Second part :—

(*a*) Revolutions of back shaft per stretch =

$$63 \div (5{\cdot}75 \times 3{\cdot}1416) = 3{\cdot}48.$$

(*b*) Total revolutions of rim shaft during spinning and twisting, i.e. until backing-off commences—

$$= \frac{1968{\cdot}75 \times 3 \times 11}{4 \times 6 \times 20}$$

$$= \frac{393{\cdot}75 \times 11}{4 \times 2 \times 4} = \frac{4331{\cdot}25}{32} = 135{\cdot}35.$$

(*c*) This 135·35 represents total revolutions of rim up to commencing backing-off, but only 80 per cent. of this total is made as carriage moves out—

$$\frac{135{\cdot}35 \times 80}{100} = 108{\cdot}28.$$

(*d*) We are now in a position to state a kind of speed calculation that will give the back change wheel required—

$$\frac{108{\cdot}25 \times 21 \times 15 \times 30 \times 48}{3{\cdot}48 \times 26 \times 80 \times 97} = 69{\cdot}3.$$

The two answers required are therefore :—
(1) 69·3 drawing-out wheel ; (2) 82·03 twist wheel.

Defects in Working of a Mule.

(*a*) Insufficient nosing motion, (*b*) too early or too late unlocking of the fallers, (*c*) the winding catch lipping at the commencement of winding, (*d*) the backing-off and drawing-up friction cones slipping. Describe the result of these defects in each instance.

(*a*) Insufficient nosing motion generally shows itself in the cop noses becoming too soft, loose, and bulky, and possibly in the counter faller riding a little too high at the finish of the run-in, and occasionally even tending to snarl the yarn at unlocking. A glance at the motion itself usually helps a practical man to decide any particular case of neglect of the nosing motion action.

(*b*) If the fallers unlock too soon the most common result is snarling of the yarn at almost every spindle, although the cop noses may be quite firmly built. Cut and broken yarn is the most common result of the fallers unlocking too late, and this often shows itself most at the out ends of the mule. A practical man standing at the end of a mule would probably detect thin-looking places or partially cut yarn in glancing along the length of the machine.

(*c*) When the winding catch slips at the commencement of winding the counter faller rises too high, and then at the finish of the run-in there will probably be snarls in the yarn, although at the termination of the next run-in the threads may be of the normal tightness, because the catch has not slipped that time.

(*d*) When the backing-off friction slips the mule will back-off in a slow and erratic manner, and may fail to back-off at all on some occasions. Probably also the friction will get very hot, although many backing-off frictions become hot even when giving very effective backing-off, due to acting as a brake to check high rim shaft speeds. When the drawing-up friction slips the mule carriage will draw up in a slow and variable manner, and not only give a reduced production, but will also often break some of the threads. Frequently also defects in the cop shaping have been traced to slip of the drawing-in friction and erratic drawing up of the carriage. The more usual results, however, are reduced speed of the machine and irregular lighting at the back stops.

"Squaring" a Mule Carriage.

"Squaring" a mule carriage may mean the rather big operation of going through a mule carriage by an expert fitter in order to line up the tin rollers, the fallers, the spindles, the carriage itself, or any of its attached parts. Or it may mean—and usually does mean—the comparatively small and somewhat frequent business of a minder getting his carriage to move about, and alight in and out in as straight a line as possible. The minder must rely upon his carriage and squaring bands for this purpose, the former being the more important of the two sets of bands. The carriage bands pull the carriage outwards, and help materially in pulling it inwards, and are distinctly more important than the squaring or under carriage bands in putting a carriage into a straight line. If a thorough re-squaring up is intended it may be as well to either slacken the squaring bands off or else to put them all at a reasonable working tension as a preliminary towards squaring up by the carriage bands. There are naturally some differences of opinion and practice among minders in regard to the best exact method of procedure in squaring up, but it is good practice to stop a mule a nice way out from the roller beam, ungear the back shaft box, so that the back shaft scrolls are free to yield to the bands, and measure accurately from the rollers to the spindle point, taking first a position not far from the headstock, leaving the nearest bands at a suitable tension, and taking care the back shaft scrolls are not turned so as to be "knocking out" too slack or too tight. Measurements may be made at each mule end and at each point in the length of the mule near which there are carriage bands, and the latter tightened or slackened as required to obtain a straight line of carriage. If a side shaft were used instead of quadrant bands or chain, then care would be needed not to upset the quadrant adjustment. It might be advisable to go over the measurements a second time to note what effect altering one pair of bands has upon another. Slight finishing adjustments may be made by the squaring bands. Stretching of bands, variations in temperature, and attempts to alter the inclines are causes of carriages getting out of line. If a carriage is out of line the threads may be snarling at one point in the mule length, while they may be cutting and breaking at another point.

Weight on Fallers of Mule.

The amount of weight on the salmon head levers and the tension of the springs for the winding fallers or amount of weight when weights are used. There is no hard and fast law possible for mules generally. Even with the counts of yarn equal, good cotton, plenty

of twist in the yarn, well-made rovings, uniformly drafted cotton, well-lined carriages, well-set fallers and faller wires, and well-built cops, will all tend to permit more counter faller weight to be applied than will the contrary conditions. As a general law the heavier the counter fall weights and the heavier must be the weights on the winding fallers when weights are used, in order to secure prompt changing of the fallers when they are unlocked, and to prevent the top wires knocking down easily when spinning. The best and most common-sense laws are as follows :—

1. Put as much weight on the counter fallers as may be necessary for producing sufficiently hard cops, so long as the weight breaks few or no threads in backing-off and winding on.

2. Place as much weight or spring tension on the winding fallers as may be necessary to promptly reverse the fallers when the latter are unlocked, and that will prevent the winding wire from being easily pushed or knocked down during spinning.

Mule and Ring Weft.

Experience has demonstrated that if ring and mule wefts are spun from equal cottons, with equal twists, of equal counts, and both rings and mules in good condition, there is a tendency for the mule yarn to give a somewhat fuller and more oozy yarn, and this affects the cloth in the direction we naturally expect from this. Printer's cloth from ring and mule warp yarn, spun at the same mill, has been known to pull out considerably longer per piece from the mule warp yarn, due to the stretch or elasticity being greater. Local circumstances, however, affect such questions as this, and therefore we hear various expressions of opinion in regard to mule versus ring-frame yarn. One person will definitely and unhesitatingly state the ring yarn is stronger than mule yarn when spun under similar conditions, while another be just as definite the other way.

On the ring-frame the difficulty of spinning weft is not only due to requiring the weft upon very small pirns or even on the bare spindle, but also because weft yarn is usually required soft twisted. The two requirements combine to give bad spinning and poor yarn unless a good price is paid for the cotton. Using rings of small diameter, picking the best tenters, using well-built pirns of as large diameter as permissible, giving a good inclination to the roller stands, and placing the spindles a good distance below the rollers are common methods of diminishing the trouble of spinning weft upon the bare spindle of the ring frame. Anti-snarling motions, travelling thread boards, and special copping motions also have some claims upon our consideration in this connection.

Ring-Frame Travellers.

The first consideration in regard to the weight of traveller is to get that traveller which appears to give the best spinning and the best bobbins. If we have excessive breakage of threads, and note that the ballooning of the threads is only of limited extent, we may try a lighter traveller and reasonably expect better results. If, on the other hand, we note an excessive amount of ballooning we might put on at least one count heavier traveller. If the bobbins were very soft and not holding sufficient yarn, we might with advantage put on a heavier traveller so long as it did not lead to excessive thread breakage. A good quality of cotton will, of course, permit a heavier traveller, and may even permit this to be so heavy that separators become unnecessary, although it is not advisable to have the threads binding overmuch upon the top edges of the bobbin.

(*b*) Extra speed of spindles tends to throw out the threads, and cause them to balloon more, but is met again by increased air resistance, while the problem of centrifugal force must also be considered in this connection.

In a recent example of reducing a ring-frame from 8,000 to 6,000 revolutions of spindle per minute the writer was able to work with the same size of traveller in each case, the rovings being of good quality.

(*c*) An increase of twist will usually increase the strength of the yarn, and this will naturally permit the use of a heavier traveller, should this be considered advisable, having regard to all the circumstances.

(*d*) When the diameter of the ring is greatly in excess of that of the empty bobbin it is more difficult for the thread to pull the traveller round than when the two are more nearly alike. As a consequence of the increased strain applied to the yarn it is likely that the larger diameter of ring would require a somewhat heavier traveller.

When testing with an unknown reel some testers will use an accurate steel tape measure to see if the periphery is exactly 54 inches. This is more in cases of trouble or dispute.

Scales for weighing yarn when wrapping should be kept really true and turn for less than half grain, and to keep weights genuinely true they should be lifted with special tweezers. Weights kept in a proper small box or drawer and scales inside a glass case.

In all kinds of scales the slightest accumulations of fibre or dirt should be guarded against.

In an important test case it was found that a sliding weight had accumulated on its inside corners, an almost imperceptible portion of dirt which distinctly affected the result.

Ordinary scales, quadrants, and six or eight sided bars with

counts marked on, need making very perfectly and accurately, and keeping in that condition.

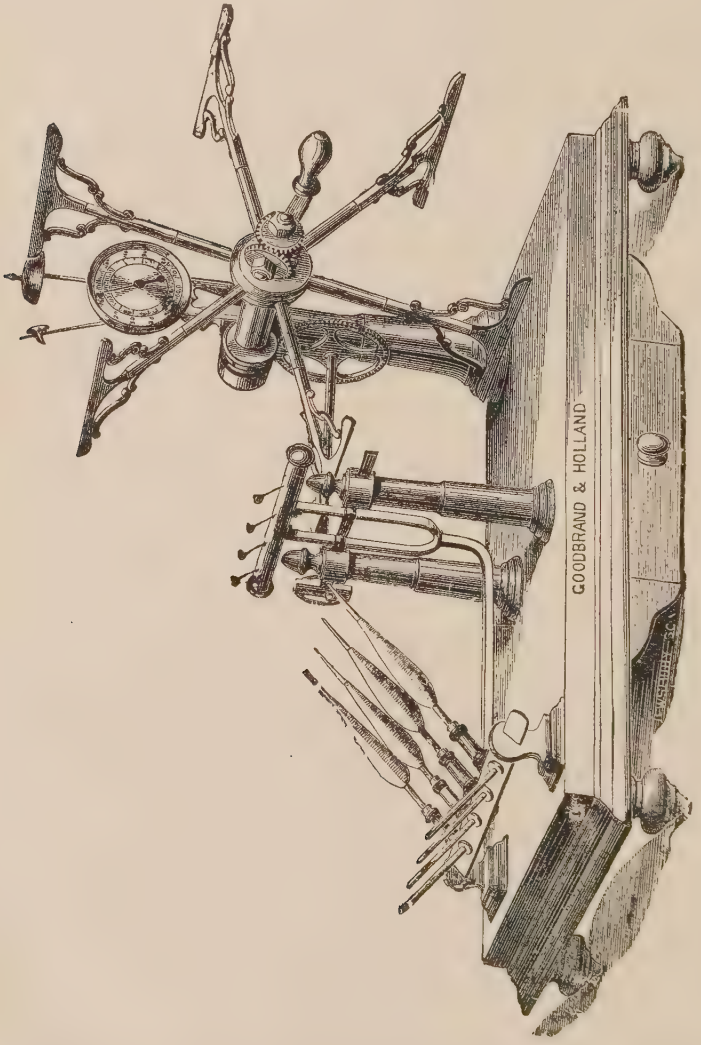


Fig. 111.

For most yarn testing, pennyweights are not much in favour, grain weights being recommended.

With a yarn balance the pointer should swing to an equal degree on both sides to indicate exactness.

A balance may be tested with an equal number of grains in each pan, or even judged when it is empty.

Custom varies in number of leas weighed together, some firms requiring four together, some two, and others each lea to itself.

Wrapping is often done at the top of cops, but tension of yarn sometimes varies at different parts of the cop.

To prevent "topping up" by the spinner using a trifle more ratch or "knocking out" slightly sooner, overtightening the threads, or applying extra and temporary tension in other ways when it is wrapping time. Also to get the best average working conditions some firms wrap the cops before they are full; at any rate occasionally.

If very damp yarn from the conditioning room be wrapped in a very hot room and possibly in the glare of the sun, the counts will come out finer than if the yarn were wrapped in the conditioning room or damping cellar. Similarly yarn direct from spindle point may be expected to wrap finer than the same yarn later from the conditioning room.

In some cases of testing under dispute, cops may be weighed before reeling, the whole cops then reeled to find the length and a proportion then established. This is supposed to give count in correct condition, but is too much trouble for any average mill wrappings.

A rule which has been given is:—

$$\frac{100 \times \text{yards wrapped}}{12 \times \text{grains weighed}} = \text{counts} = \frac{8{\cdot}33 \times \text{yards}}{\text{grains}}.$$

The more usual rule is to divide the weight in grains into the constant 1,000 to obtain counts when one lea of yarn is taken. Obviously this is obtained from cancelling certain constant numbers, and on the same basis other rules and constants may be obtained. For quick testing by wrap reel, instead of taking a lea of 120 yards, we may take 8 revolutions of reel or 12 yards of yarn and the grains weight of this into 100 to get counts.

In coarse yarns especially the overlapping of yarn on the wrap reel may give from 1 to 2 per cent. excess length and make the counts appear coarser than they really are. For this reason a reel should have a good width of traverse, and in dispute cases it is possible to use reels which have such a wide traverse as to give very little overlapping. A corrective may be possible in using a reel of the slightest bit less circumference.

Ordinary Wrap Reel (Figs. 111-112).

The illustrations show ordinary wrap reels for four cops as standardised and very generally adopted for many years past. There are many reels for wrapping seven cops or seven leas at one time and this of course means wrapping one full hank at a time.

Most mules, however, have long favoured the four lea wrapping reel as giving a sufficient number of leas in once wrapping, without being very cumbersome or very wasteful in yarn. One revolution of the handle gives two revolutions of the reel, giving a nice balance of hand speed and reel speed. The fixed bevel of the three, acts as a movable hinge or fulcrum for the centre bevel, and the reel being twice as far from the fulcrum as the handle, in this way one revolution of handle gives two of reel. Either one firm or the other will put stiffening bars across the reel cross-bars to give strength.

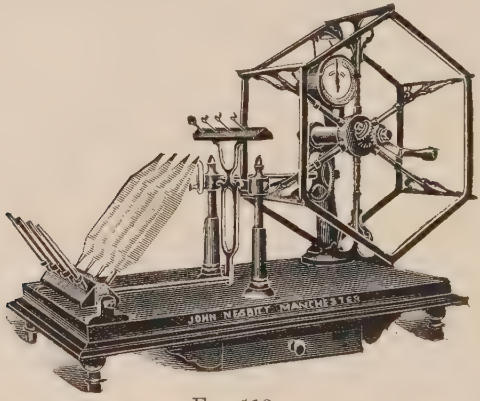


Fig. 112.

Use of Constant Number 1,000.

It has to be remembered that in cotton spinning 840 yards = 1 hank, and the number of hanks contained in 1 lb., or 7,000 grains, equals the counts. If we divide 7,000 grains by the grains in a hank the quotient will be the counts; therefore, if we take $\frac{1}{7}$ of 7,000 grains and $\frac{1}{7}$ of a hank, it gives just the same result. That is to say, taking 1,000 grains for the dividend, and a lea of 120 yards as the divisor, will give exactly the same quotient as with 7,000 as the dividend and a hank of 840 yards as the divisor.

This may be illustrated by counts 1's. Suppose a hank to weigh 1 lb., or 7,000 grains, then $\frac{1}{7}$ of the hank, which is a lea of 120 yards, would weigh $\frac{1}{7}$ of 7,000 grains, that is to say, 1,000 grains.

$$\frac{7{,}000}{7{,}000} = \frac{1{,}000}{1{,}000} = 1\text{'s.}$$

A general rule which can be used for finding the counts, alike for the lap from the blowing-room or the sliver lap machine, the sliver from the card, comber or draw-frame, the roving from any of the bobbin and fly-frames, or the yarn from the mule or ring-frame, is as follows :—

Take for a dividend the constant $8\cdot\dot{3}$, multiplied by the number of yards of cotton wrapped ; for a divisor the weight of the cotton reduced to grains. For the case specified in this question this would give :—

$$\frac{8\cdot\dot{3} \times 120}{\text{weight of 120 yards.}} = \frac{1{,}000}{\text{weight of 120 yards.}}$$

The constant $8\cdot\dot{3}$ is simply obtained by cancelling 7,000 by 840.

A stand is shown in Fig. 116 such as may be used if required for placing hanks of yarn upon, before, or after testing.

Most mills don't trouble in this matter.

Knowles' Yarn Balance.

The ordinary plain type of scale or balance, kept in a well enclosed case, with easy sliding door, finely balanced, to turn at $\frac{1}{50}$th of a grain, weights handled with small nippers, weights tested or changed as required, has always been preferred by many practical men connected with the cotton trade.

There are, however, specially designed scales of a distinctive character, adapted to the particular requirements of testing cotton yarns made by Goodbrand and Co.

One of the oldest and most used of these is Knowles' yarn balance, which is an exceedingly sensitive balance for testing counts, and at the same time indicating the counts on a self-contained counts bar, without any reference to an external table and without any calculation. It works without the ordinary dwts. and has its own kind of weights and slide pieces.

The counts are indicated on the engraved bar, the apparatus being constructed to suit any special range of counts required.

It can be adapted either to cotton, worsted, linen, or other yarns and for one or more leas.

There is a lever for lifting the scale pans from the box bottom when testing yarn.

Behind the beam, there is the counts bar of six or eight flats or sides, engraved and silvered. Each flat is marked with a letter A, B, C, D, E, F as required. Corresponding with these sides and letters there are slide pieces or indicators, and also weights, each slide piece and each weight with its letter A, B, C, D, E, or F.

Weight in left hand pan, yarn in right hand, slide piece moved until a balance is made. If the flat or side on scale marked B served for yarns 40's to 60's, and a person knew his yarn came inside that range, then the bar would have its flat marked B turned to the front.

The weight marked B put in the left-hand scale and the slide piece marked B put on the cross bar or slide bar of the balance. This slide piece would be moved along the slide bar until a balance was obtained. The centre line of the sliding piece would then point to the counts on the bar behind.

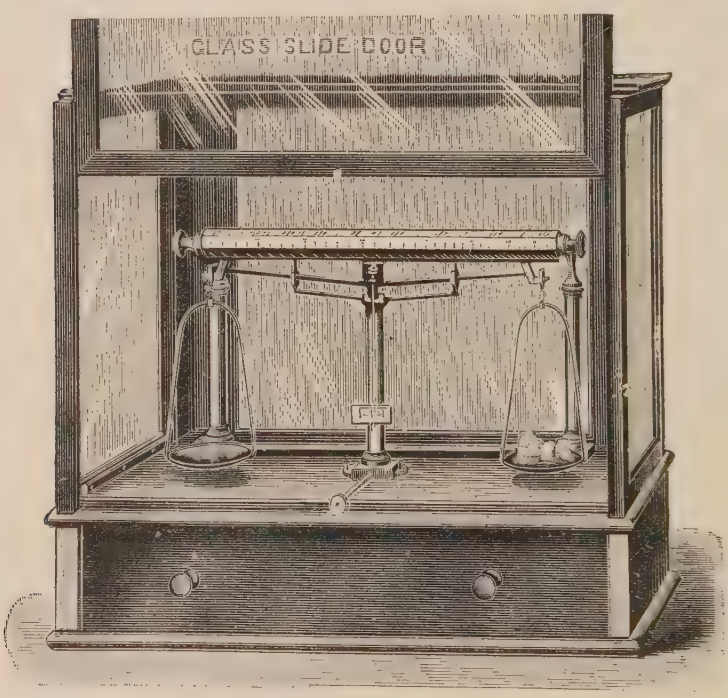


FIG. 113.—Knowles' yarn balance.

Raw Cotton.—First testing then begins with the purchase and selection of cotton, and should disclose fundamental features, such as length and strength of fibre, or staple, brightness, and freedom of leaf, or grade.

Research.—Extra attention is now given to anything coming under the heading of research or testing, because of the large sums of money apportioned thereto, and engaging the services of individuals possessing special qualifications for the work.

Sometimes small black gauges, rules or scales are now used to aid in quickly judging exact lengths of fibres. Also devices for better judging the preponderating and mean length of fibre in a cotton mixing so that rollers may be set better to average.

Scutchers.—At scutchers all full laps should be weighed and weights put down. Also occasional weighings of short lengths of cotton sheet or lap—1, 2 or 3 yard lengths—broken or cut off to special frames or gauges, and with very great care.

Slivers.—Occasional testings at carding engines usually show a somewhat wide range of variation. Combers require testing for counts of lap, counts of sliver, and per cent. of waste. The last head of draw-frame is a very notable, vital, and indispensable position for testing counts. Generally speaking, even if card slivers vary greatly from the card, the variation will have become very moderate at the second passage of draw-frame, and almost lost at the third head.

Draw-Frames.—A draw-frame test of from 2 to 6 yards of sliver is intended to disclose whether counts are too coarse or fine, quite as much as to discover variation between lightest and heaviest weighings.

Fly-Frames.—A test of 15 yards daily from slubber is a good check on the draw-frame wrapping. A 30 to 60 yards test twice per week at intermediates and rovers is the custom in some mills.

A second important test at fly-frames is to wrap the same bobbin at top, middle, and bottom of set, in order to discover any variations due to errors in the winding-on, or in the cone drum work.

Winding-on of front row bobbins is sometimes compared with winding-on of back row bobbins, since the front row tends to wind softer bobbins and finer rovings unless front row cotton is wrapped one time more round presser or half turn more round flyer top. This is due to greater distance from roller to flyer top, and more horizontal nature of the roving for front row.

To test for twist per inch at the fly-frames—count exactly the revolutions of flyer or spindle for one of the front roller. The inches of roller circumference divided into the equivalent spindle revolutions will give as quotient the twist per inch.

To Test Counts of Sliver and Rovings (Fig. 114).

The ordinary wrap reel or wrap block used when testing the counts of slivers from cards, combers, or draw-frames, differs materially from the one in ordinary use for yarns.

In principle the card-room wrap block has not been altered for fifty years or more, but it has been altered in detail.

The yarn wrap reel in this country has been long standardised

at $1\frac{1}{2}$ yards circumference; but the sliver wrap block has long been fixed at 1 yard periphery.

Two, 3, 4, 5 or 6 yards may be taken when testing slivers—according to individual ideas. Afterwards weighed on ordinary scales.

Some firms in fine spinning yet prefer to measure off on a table 2 or 3 yards.

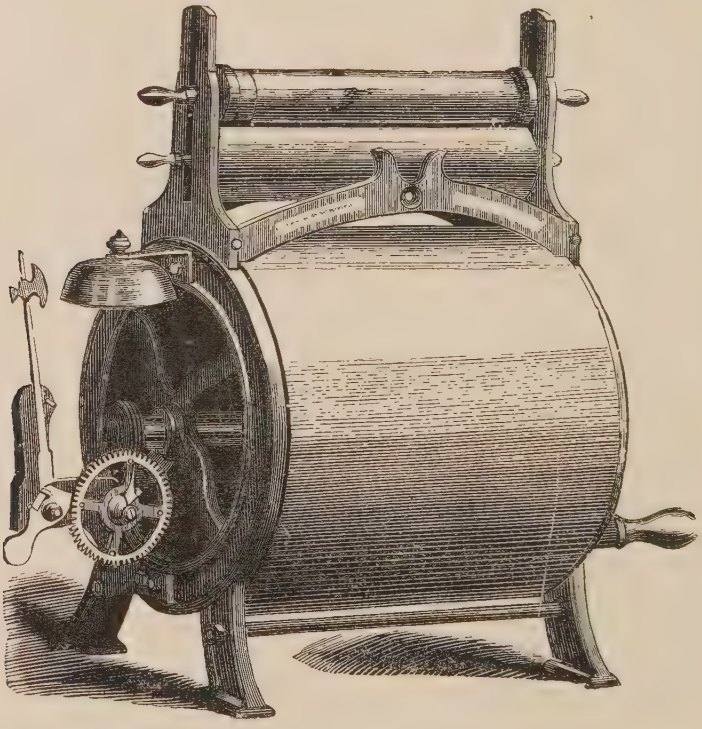


Fig. 114.—Card-room wrap block.

For the thinner, twisted slubbings and rovings use the same machine, but take longer lengths, perhaps 15 yards slubbing, 30 yards from intermediate frames, and 60 yards roving or fine jack. In such cases the bell may ring every 15 yards. A practical tester over a limited range often knows the proper weights, but in any case reference may be easily made to proper counts and weights tables. Results should be duly noted for ready reference by the manager or other responsible person.

Wrapping of Slivers.

Time permitting it is good practice to wrap finisher draw-frame for counts three times daily—morning, noon and night, allowing for a variation of about 1 grain per yard up or down from standard. With 60's draft pinion and wrapping 61 grains or 61¼ instead of 60 grains, then a 59's pinion might be applied.

In fine spinning 2, 3 or 4 yards of sliver may be taken for wrapping and measured off on a board, and sometimes this is done every two hours, and occasionally at less intervals if a separate testing operative is employed. For American cotton often 6 yards of sliver taken by means of wrap block of 1 yard circumference.

Card slivers often vary 2 grains per yard, and comber slivers 1 grain per yard, but the draw-frame has been frequently proved to be a really great machine for giving uniform work, from Arkwright's time to the present.

Once or twice a week for wrapping at the comber, and once per week often considered enough for wrapping counts, and some firms only occasionally wrap cards unless there is special trouble on.

Testing for Strength and Elasticity.

The most used mill method of testing cotton yarns for above purposes is to take a lea or 120 yards from each cop by means of the wrap reel of 54 inches circumference, and to place this lea upon the two hooks of a strength testing machine specially constructed for the purpose. The machine contains an indicator face and finger, which show the amount of pressure exercised upon the yarn. The lea of yarn being placed on the two hooks, the lower hook is moved downwards by means of a suitable handle and worm arrangement. This puts the yarn under tension, and exercises a proportionate pull upon the upper hook, which pull is transferred to a spring and weight arrangement, so that the weight is moved upwards at the same time, causing the indicator finger to move round. The weight is prevented from falling backwards by a catch and concentric rack for the catch to fit into. Suppose the indicator finger pointed to 80 lb., then that would be the breaking strength of the yarn.

The same testing machine is often fitted with a small arrangement by which an idea of the stretch of the yarn can be obtained. Connected to each hook may be a pointer referring to certain marks made upon the stem or tube of the testing machine.

Suppose in testing one lea of yarn for strength we also noted its amount of stretch, and the lower hook moved downwards 3½ inches while the upper hook only moved 1 inch downwards, then the stretch would be the difference between the two, or 3½ minus

1 equals 2½ inches of elasticity as it is often so called, although the term "stretch" is more accurate.

In many cases practical men depend much upon simply testing the yarn manually. A portion of thread is extended between the hands and delicately pulled until it breaks, by which time a fair idea will be conveyed to the mind of an expert as to the comparative amount of elasticity and strength possessed by the yarn. Single thread testing machines are in use in some cases. As regards the precautions for avoiding error, perhaps the best is to check the results by making several tests and taking an average of them. In some cases the testing machine is revolved by power from a steady, slowly revolving shaft, and this practice undoubtedly tends to give more accurate results. In any case too much care cannot be exercised in making the tests properly in all respects. A foot per minute or 2 inches in 10 seconds is regarded as a good working speed for the bottom hook to travel at.

As regards strength alone, it might be said that sewing thread most certainly requires strength, while warp yarn requires elasticity, and, for the matter of that, strength, though not as much of the latter property as sewing thread.

Fig. 115 is an illustration of a lea strength tester turned by hand.

Lea Power Strength Tester.—A power driven machine should be timed to have the lower hook moving at the approximate rate of 3 inches in 15 seconds. These machines should be occasionally tested for accuracy by standard weights. In a well-known make of lea strength tester, power driven, the lower hook continues to descend after the thread breakage until the driving bevel is drawn automatically into gear with the opposite bevel which again traverses the lower hook to its highest position, after which the driving bevel assumes a central position, disconnected entirely, so that the hooks and working parts remain out of gear until reconnected for a fresh lot of yarn.

A finely pitched quadrant rack and catch, maintain the clock face finger in position until unlatched by the operator.

For inspection a cylinder something like a card doffer may be blackened, power or hand driven, fitted with easily unlatched traverse motion, supplied with creel for half a dozen or more cops, and used for yarn comparison at the spinning mill. Most mills don't trouble to this extent.

Lea Testing.—Lea testing is very convenient for strength testing at the same time as testing for counts, the process being very straightforward, in stripping each lea of yarn from the wrap reel, breaking it on the lea tester, then weighing for counts. If a lea of yarn, or 80 wraps or 160 threads of 18 inches each, contain thirty or forty, fifty, seventy or any other number of weak places, these

weak places will break first, or cease to give "pull" in proportion

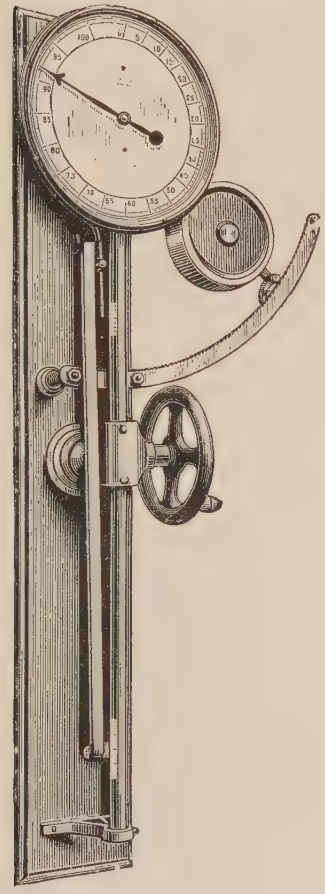


Fig. 115.

Fig. 116.—Hank stand to hold hanks ready for use, yarn held on bird cage bobbins.

to their number, finally and quickly giving a good guide to yarn

strength and condition in spite of adverse criticism from various exponents of single thread testing.

If the lower hook of the lea tester descends $2\frac{1}{2}$ inches and the upper hook $1\frac{1}{2}$ inch the difference of 1 inch represents the "stretch" of the lea if multiplied by 2 because of each lea dividing into two sides or sets on the tester. The steady nature of applying the "resistance" or the "pull" to yarn in strength tests is not always obtained in actual winding, weaving, reeling, or other process often then taking the form of plucking or hammering of the thread. For this reason it has been argued this principle should be more used in testing appliances.

Counting glasses, microscopes, specially mounted magnifying glasses, and what may be termed micro-telescopes, are more or less used for close examination of fibres, yarn, or cloth.

Breaking Weights.—In ten test trials, 20s count's of carded ring weft gave $19\frac{1}{2}$'s counts × 141 lb. per lea as average. Carded mule weft gave $20\frac{1}{2}$'s counts × 94 lb., these being doubling wefts.

A well-known American machinery firm (Messrs. Draper & Co.) some years ago gave the following two tables of strength for cotton yarn :—

Breaking Weight of American Warp Yarns, per Lea. Weight given in Pounds and Tenths.

Number.	Breaking Weight.	Number.	Breaking Weight.	Number.	Breaking Weight.	Number.	Breaking Weight.	Number.	Breaking Weight.
		20	88·3	**40**	44·6	**60**	31·7	**80**	24·6
1		21	83·8	41	43·8	61	31·3	81	24·3
2		22	79·7	42	43·0	62	30·8	82	24·0
3	530·0	23	75·9	43	42·2	63	30·4	83	23·7
4	410·0	24	72·4	44	41·4	64	30·0	84	23·4
5	330·0	25	69·2	45	40·7	65	29·6	85	23·2
6	275·0	26	66·3	46	40·0	66	29·2	86	22·8
7	237·6	27	63·6	47	39·3	67	28·8	87	22·6
8	209·0	28	61·3	48	38·6	68	28·5	88	22·4
9	186·5	29	59·2	49	37·9	69	28·2	89	22·2
10	168·7	**30**	57·3	**50**	37·3	**70**	27·8	**90**	22·0
11	154·1	31	55·6	51	36·6	71	27·4	91	21·7
12	142·0	32	54·0	52	36·1	72	27·1	92	21·5
13	131·5	33	52·6	53	35·5	73	26·8	93	21·3
14	122·8	34	51·2	54	34·9	74	26·5	94	21·2
15	115·1	35	50·0	55	34·4	75	26·2	95	21·0
16	108·4	36	48·7	56	33·8	76	25·8	96	20·7
17	102·5	37	47·6	57	33·4	77	25·5	97	20·5
18	97·3	38	46·5	58	32·8	78	25·3	98	20·4
19	92·6	39	45·5	59	32·3	79	24·9	99	20·2
								100	20·0

Breaking Weight of English Warp Yarn given in Pounds.

Number of Yarn.	Ordinary Cotton.			Long Stapled. Egyptian or American.		
	Com.	Fair.	Super.	Com.	Fair.	Super.
12	135	155	185	—	—	—
16	90	100	112	—	—	—
20	75	85	98	—	—	—
26	60	68	78	80	90	100
30	50	55	62	70	80	90
32	45	50	58	65	75	85
36	40	46	53	52	60	68
40	36	40	44	50	55	60
50	—	—	—	40	45	50
60	—	—	—	30	33	37
70	—	—	—	26	28	31
80	—	—	—	20	22	25

Examination of Tester.—A strength tester of almost any kind may be occasionally tested with a standard weight to note if a correct reading is obtained. If leverages for yarn and weight were equal or even leverage × weight, a definite weight on a yarn hook would produce its own weight on the scale by the pointer; but leverages are not always equal. In any case a standard weight will produce an accuracy test.

Single Thread Testing for Strength.

Writing in 1922, it may be said that for more than twenty years some makers of testing appliances, research people, textile teachers, and others, have proclaimed the merits of single thread testing, as against those of lea or half lea testing. Testing of short individual threads instead of lea lengths reeled into wraps of $1\frac{1}{2}$ yards each, or 18-inch lengths on the tester, so that each lea makes 80 wraps or in effect 160 threads on the hooks of the strength tester.

Arguments for single thread testing run somewhat as follows: Threads are tested in the same way as they are used in the loom or elsewhere—i.e. one thread at a time; it shows the real strength and stretch of yarn under test; it shows how the yarn varies in these respects in each individual and consecutive length tested; it shows the frequency and degree of recurrence or regularity of faults in the yarn, and may give a clue to their cause; it shows the magnitude of the fault; it localises defects or merits; the lea test only indicates an average result, whereas the single thread test is more searching and variations in strength and stretch therefrom are more indicative of the real quality of a yarn, and it more

genuinely informs a user whether he has a good yarn or not to work with.

Much ingenuity, money, and ability have been expended in perfecting various makes of single thread tester, and there is undoubted scope for these appliances, especially among school men, research men, and users of yarn who are often in the predicament of only having short lengths to test with ; also among quality spinners who desire to explore any convenient avenue in determining exact merits and demerits of yarn. In doubled yarns individual thread testing for strength and elasticity was in some favour long before the advent of the modern appliances for single spun yarn.

In spite of all the above, the fact remains that by far the greater proportion of spinners, yarn agents, and users of cotton yarn do their testing for strength and elasticity by the lea tester, and all experience demonstrates that this machine gives expeditious and sufficiently reliable testings for nearly all practical mill and commercial purposes, taking care not to compare single thread tests with any lea tests.

The author has personally tested innumerable samples of yarn, has witnessed and taken note of others *ad lib.*, and can testify that all experience proves that a yarn is weak or is strong when the lea tester says so. All the better if the lea tester is power driven, with lower hook descending at the rate of 1 foot per minute or 4 inches in twenty seconds, kept very steady, clean, smooth running, and correctly recording. Lea testing wastes rather overmuch of good yarn.

The single thread test is more searching, more likely to localise faults, more suitable for short lengths, but it is not in its favour that several tests are necessary in order to obtain a mean or average which can be relied upon to indicate the general condition of a yarn. You cannot condemn or praise any cotton yarn on the results of either one or two tests of 18-inch lengths.

The present strong tendency towards textile research work may help to make single thread testing more used in actual business transactions. Some good firms like to have both occasionally—one to help or check the other.

Engineers have learned to measure to the $\frac{1}{1000}$th of an inch, is there scope or need for such fine work in textiles, and can cotton yarn be treated as if it were steel?

Some consider single thread testing is more comparatively valuable for stretch than for strength.

Twist and Moisture in Strength Tests.—The amount of twist in a yarn affects both strength and stretch, and when the twist is in excess of the maximum economic amount, the strength diminishes, whereas up to that point twist increases strength. In some yarns the economic limit is reached with about $4\frac{3}{4}$ to $5\frac{1}{2}$ of a constant

× square root of counts. Lea testers may be for different strengths. some machines registering up to 120 lb. maximum, others up to 300 lb. maximum. One half lea may be taken for very strong single yarns. The average of ten breaking tests is considered a full test in dispute cases. Sakel cotton has its twist limit reached much sooner than other cottons; say not to exceed the standard 3·606.

The strength of cotton yarn increases with added moisture up to a limit; owing to the fibres bending round each other more easily and so producing more "coil friction" between the fibres themselves.

The stretch may be rather higher for wet than for dry yarn owing to the shrinkage which takes place when the thread is absorbing moisture. Probably the reverse of this is true when a thread is over dried. Increased elasticity of cotton yarn due to moisture is possibly due also to greater flexibility in the fibres, permitting them to get closer together, lessening their curvature and extending their length.

When a thread is very soft, a little added twist makes considerable difference to its diameter, but if a thread is already hard, a little extra twist makes little appreciable difference in diameter. Often the term elasticity is taken to mean stretch up to breaking point, but this is "stretch," whereas elasticity means recoverable elongation.

Hydraulic Strength Tester (Single Thread).

One of the earlier forms of single thread strength tester was Mr. Smith's hydraulic thread tester, an example of which was operated many times by the present writer when it first came out.

The thread was clamped in a beam jaw at one end, and the other end of thread in a sliding jaw after being tensioned by a small weight so that every thread should be under the same tension, and therefore more likely to accurately record stretch.

The thread being duly clamped at both ends, a spring motor was started so as to move the sliding jaw, pull at the thread so that the thread lifted a pad from the mouth of a water pipe, and water could flow into a measured and marked liquid vessel hanging on one end of the lever supported by the thread. When the thread could no longer sustain the increasing weight of water, breakage occurred, and the pad again covered up the mouth of the water pipe. The breaking load or strength of yarn could then be read off in grammes or ounces on the scale in vessel supplied therefor.

The sliding yarn jaw was also made to indicate the stretch.

The complete machine was also equipped for twist testing, but most people prefer separate appliances for this.

Improved machines on such principles as above are now available.

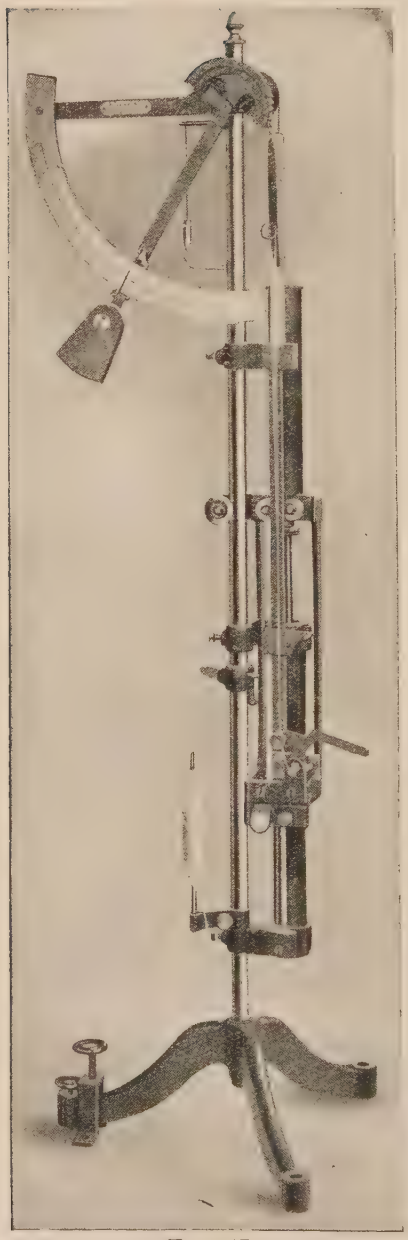


Fig. 117.

Baer's Single Thread Tester.

This machine is totally different in design and principle from Smith's and has become somewhat popular.

For single thread testing many of these machines have come into use.

The machine is built upon a vertical pillar which is supported by a tripod capable of resting upon or fastening to a table, the machine being portable and having a foot screw for levelling, and a plummet for indicating the level.

The strength is registered upon a quadrant on which there are two scales—one for ounces and the other for pounds. The indicating finger or pointer is sufficiently long, and an extra weight is added to this when pounds are to be tested and registered. 18-inch lengths of yarn may be tested between the jaws, but shorter lengths can easily be adjusted for. The weighting agent is a dead weight in the form of a vertical weighted plunger of brass or brass covered, which can only move slowly down owing to part of it being inside a vertical vessel containing thick oil which resists the plunger so that a steady test is obtained. The lid of the piston is perforated so that oil may slowly pass from the under to the upper side of piston. Olive oil or cylinder oil have been in use, and should be kept in a good-

working circulation in every way. Baer's agent is Mr. Isherwood of Manchester.

Brackets for the central pillar are the brackets for the oil chamber. The registering quadrant is supported at the top of the pillar.

A catch is attached to the plunger framing, by which the plunger is held in its highest position while the yarn is being placed in testing position. Also a small catch to hold the quadrant pointer at starting point until ready for setting on. The recording arm is compounded with a half-circle chain holder to which is connected the upper yarn grip. Pulling at this holder moves the recording finger up the marked quadrant which contains fine teeth on its upper edge, so that a small catch in the long recording finger fits in the quadrant teeth and holds the finger at registration point when the thread breaks. The yarn for testing is attached at the top to the quadrant finger connection, and at the lower end to the moving clip or holder in the plunger.

Washers are provided in both upper and lower holders so that the yarn may be firmly gripped without being injured by the screwing up fast.

When ready for testing, the catch for holding the quadrant finger is released and then the main catch which holds all the plunger frame up.

The entire plunger descends at a steady speed, the lower yarn clip lever takes the vertical elasticity rod down, and the recording finger moves up the quadrant.

When the thread breaks, the yarn strength remains indicated on the quadrant, the lower lever clip releases the vertical elasticity rod from movement, and the plunger is free to descend to the bottom if permitted.

The stretch or so-called elasticity is registered on the vertical stretch rod. The washer of the upper yarn clip is shaped like a small grooved pulley so that when required the thread may be simply passed round this pulley and attached at both ends to the bottom holder, thus giving a double thread test. The Fig. shows Baer's machine as used at Bolton Technical School since 1911 but with slight alterations.

Nesbitt's Single Thread Tester.

There are several principles of construction and operation which are fundamentally the same in such machines as Baer's and Nesbitt's single thread testers, and both have been much adopted.

In each case there is the equivalent of power testing by means of dead weights released at the proper moment and yet dispensing with any such force as steam, gas or electricity for driving power.

In Nesbitt's machine the clock face, weighted lever, quadrant

rack, and polished wood framing are retained as in lea power testing but adapted to single threads.

The thread to be tested is secured to the upper hook near the clock face so as to pull as usual against the weighted lever. The lower yarn hook is compounded with a handle, piston weight, and catch arrangement, which is released for descending when ready for testing. In this case as in Baer's the piston moves in a vertical oil cylinder and there is a very satisfactory method of permitting oil to flow from below to above the piston when a test is being made and the weighted piston combination is descending. A small external pipe connects the two ends of the oil cylinder filled with a tap by which the oil flow may be regulated to suit the 2 inches in ten seconds standard rate of movement. The handle is convenient for replacing parts ready for next test. A stretch recorder is applied, so that when the thread breaks a finger is released which controls the stretch indication.

The oil flow from one end of the cylinder through an external side pipe is a commendable feature. As in the lea tester there is a sufficiently powerful force applied at a controlled speed until the thread breaks. In this single thread tester the force is a weight and the oil piston the speed regulator. In the lea tester a long worm is driven round.

Moscrop Single Thread Tester.

This possesses the very distinctive features of testing six cops or threads at one time; automatically continuing to make a good number of tests from the same cop (up to 160), and diagrammatically recording the breaking strength for every individual test. In a sense this machine analyses and records strength test results.

For 160 tests from the same cop about twenty minutes may be taken, and there are six cops or ring bobbins of yarn tested simultaneously, each thread taken at 12 inches long. There is a creel for the cops, nips to hold the yarn, a travelling carriage, a spring to resist the pull of each yarn, and the recording card.

On the inward run of the carriage the yarn is presented to the nips at the front of machine.

There is the outward run of the carriage in which a definite length of yarn is delivered from each cop; and the recording of the breaking strength on the diagram paper. The tested yarn is cleared from the nips ready for next test; springs of guaranteed temper and accuracy. This machine will probably excel other single thread testers in number of tests made in a given time, but spring testing of yarn is by no means in great favour with everybody. It is one of the most ingenious of strength testers for cotton yarn.

Briercliffe's Single Thread Tester.

Great ingenuity, much trouble and expense, the introduction or utilisation of distinctly different principles of construction and operation, become very evident from a general survey of various makes of single thread tester.

For example in the matter of gradual application of the breaking force to the thread, in single thread testers.

In some machines the breaking force takes the form of water or shot gradually running into a vessel suspended at one end of the balance lever until the thread at opposite end of lever breaks.

In other machines the long-established lea tester principle of the thread *pulling* against a weighted lever, is introduced for single thread testing, the weight being fixed but the yarn pull increasing the weight leverage; whereas in the above Smith's machine it is the applied weight which increases and not its leverage.

The ordinary quadrant or clock face indicators give the "pull" of the threads, the varying weight machines give the "resistance."

Briercliffe's machine utilises the gradually increasing leverage principle, but differs radically from the "pull" increase as in quadrant testers. Instead of the yarn pulling a weighted lever to an extended leverage, external mechanism is employed to gradually increase the leverage until the yarn "resistance" is overcome.

For a dozen years the present writer has witnessed the great efforts of Mr. Briercliffe to perfect this machine, both the first and the latest machines having been installed in the Bolton Technical School up to date.

In originality of conception and construction this machine differs from any other make.

The central feature consists of a practically plain, almost horizontal, lever having approximately equal arms of possibly 15 inches length, the fulcrum being central. The thread is quickly secured by clip to the end of one arm of lever, the other end of thread reaching downwards for about 18 inches (adjustable) to the second and fixed clip. Great praise is due for the beautifully perfect nature of the clips, and a small yarn tensioning device connected with the lower clip so that each thread is placed under the same guaranteed tension before clipping, and without any trouble.

The yarn end of the lever rests naturally in its lowest position while each thread is secured for testing.

The weight arm of the lever is slightly inclined so that a running weight on pulleys will definitely move down the arm and obtain increased leverage as permitted to do so.

There is what may be termed practically a modified gramophone "let off" motion for the running weight.

Yarn being attached for testing, a catch is released, a dead-weighted cord begins to let off the weight cord from a central drum, there being a fly-wheel and expanding brake arrangement to keep the travel of weight and increase of leverage under control. The traverse of the weight increases the leverage until the thread resistance is overcome and the thread breaks, at which moment a catch instantaneously stops the "let-off" motion.

There are removable ivory scales attached to the side of the weight arm of lever, and a knife edge on the weight frame indicates the breaking resistance.

A pen or pencil is attached to the traverse frame if desired and automatically makes a strength and elasticity diagram on a plotted and removable recording card.

Five or six weights are part of the equipment, from possibly 4 ounces to 64 ounces, with ivory rules or cards to match, so that the finest yarns or even rovings may be tested on the one hand, or very coarse strong yarns on the other hand.

A vertical slide frame is applied, which permits fixing for testing different lengths of rovings.

The yarn end of the balance lever contains a pointer working over a marked elasticity card or chart.

The whole arrangement is secured to a rectangular horizontal slab of wood, metal or marble as required, this in turn being secured to vertical pillars of brass or other material, or any other convenient fixing or support may be arranged for.

Mr. Briercliffe is a practical cotton spinner, has made a hobby of this machine, and has produced a beautifully effective, complete, original, compact strength tester, which may be easily carried about, and fixed as required.

Testing Yarns for Quality in Winding.

In a doubling mill a system somewhat as follows might be adopted to test winding quality of yarns.

Suppose a winder attends twenty-eight drums and is winding two folds.

This winder will be operating fifty-six cops at a time, and in a test the whole fifty-six may be taken, and a timing observation made from starting first cheese spool until the fifty-six cops are all run off.

Observations are taken and noted in regard to yarn breakages, soft cop noses, nicked cops, how well the cops run off at the finish of cop bottom, tendency to corkscrew, or any other special feature, but taking care not to debit the yarn with faults due to the winding frame itself or any of its parts being wrong. Much the same procedure in principle for vertical spindle winding and single end.

A prepared sheet with suitable columns and headings may be used for noting test results.

Weight of empty tubes, full weight of cops before using, weight of waste, and weight of wound yarn could all be noted if desired.

Strength Tests for Cloth.

Strength tests for cloth have developed rapidly during recent years partly on account of Government requirements—especially during the war—cloths for such special purposes as aeroplanes, and the increased demands of large customers such as railway companies, who prefer to have cloths officially certified to reach a specified minimum strength. Developments in cloth testing appliances have kept pace with requirements of large users of cloth, some testers holding the cloth samples in a horizontal position and others in a vertical one. Foreign purchasers of cloth sometimes require a certificate of cloth strength from an accredited testing authority.

It is important in cloth testers that convenience be provided for testing samples of specified dimensions, should grip the cloth in an unyielding manner, without cutting it, apply required pressure at a specified and controlled speed, or else an increase of weights.

One end of the cloth sample is gripped between movable jaws which may gradually pull the cloth against the opposing jaws, which latter may be attached to some kind of weighing, weight or force measuring or recording apparatus. The fundamental principles of cloth testing devices are much the same as often employed for yarn with every mechanical detail adapted for cloth instead of yarn. The rate of a foot per minute is the most used standard for yarn strength testing, but 1½ feet per minute is often recommended for cloth, although the character of the cloth may itself affect the speed of test.

As for yarn so for cloth, the balancing or weighting or breaking point may be reached by water or shot running into a bucket, or by the better known method of dead weight, or of a weighted lever in which the weight is fixed but its leverage is rapidly increased by the cloth pull.

Amount of elasticity in cloth varies considerably, and this may affect the speed of test. In yarn the method of testing for stretch or so-called elasticity has chiefly been to register the traverse of the upper or balance hook against the actual movement of the traverse hook, obtain the difference in extent of movement between the two, and from this the stretch. Much the same fundamental principle is sometimes adopted for cloth.

Instead of aiming at a fixed traverse speed of possibly 1½ feet per minute, the method adopted in some modern cloth testers is

to add the load or breaking weight at a constant rate until breakage occurs, and many prefer the principle of constantly increasing load rather than the uniform rate of traverse, the traverse end being loaded to an extent always sufficient to take up any extension or stretch of cloth due to increasing load, as stated. The quadrant measurement of strength is favoured for cloth as well as for yarn, with horizontal cloth.

It is quite easy in testing yarn to wrap reel the yarn into leas and test a lea at one time, although short length testers are sometimes used.

It is not convenient to test long lengths of cloth. Comparatively small pieces may be taken, as for example pieces of 4 inches width and possibly 9 inches long, or at any rate 9 inches between the opposing jaws of the tester. If a 9-inch cloth length were taken and placed between jaws only 4 inches apart it might be expected to break stronger than in jaws 7 inches apart. Sometimes cloth is cut somewhat wider than standard and dressed down to standard at the edges to ensure every thread taking part in the test. Power driving is best for cloth as for yarn.

Moist cloth may test stronger than naturally dry cloth. Several tests under identical conditions may be needed to obtain a guaranteed result.

For heavy material such as canvas, belting, motor-duck, drills, a dead weight machine registering up to 1,000 lb. may be used.

For lighter material such as Glossop printers, calico, tapes, a register up to 300 lb. may be sufficient. The ever aggressive electric drive is proving its suitability for driving yarn and cloth strength testers, as in other avenues of machinery driving.

Rooms quiet, still and clean when no running is wanted, then a handle or two moved, any one machine run to extent required, then shut off again, Corporation supply, any girl or boy to start or stop the machinery. These are electric driving advantages.

Six $\frac{1}{2}$-yard samples may be required for a practically guaranteed test. Samples 8 × 3 inches sometimes taken.

Sometimes samples specified to be 9 × 4 inches, sometimes 9 × $6\frac{5}{8}$ inches, the 9 inches between the opposing jaws when set for testing. To get the grip on the cloth a sample may be 11 or 12 inches long leaving 1 to $1\frac{1}{2}$ inch for each jaw to grip.

If the test length be 7 or 9 inches it means this amount between the jaws; standardisation of cloth lengths for strength testing yet leaves room for improvement.

Size of Sample.—Desirable sizes of samples submitted for testing are stated below :—

1. *Moisture Test.*—Raw cotton, 1 to 3 lb. One yarn bundle. One to 2 lb. of cops.

2. *Counts Test.*—One yarn bundle. One lb. of cops.

From Cloth.—Two square yards for warp and weft or for weft only, but only 1 square yard for warp only.

For Strength.—One to 2 lb. of cops, or one bundle if in bundle, both for lea and single thread test.

Yarns from cloth the same dimensions of cloth as for counts.

Humidity in Testing.—Whether it be for strength or counts the question of humid versus dry atmosphere must receive attention in order to obtain accurate results, the question referring to raw cotton, cotton slivers, cotton yarn, and cotton cloth.

The material being subjected to ordinary atmospheric conditions then wet days may show coarser counts and greater strength than testings on a dry day.

Rooms with uniform controlled humidities are sometimes used for guaranteed results.

In testing mule cops in the spinning mill, often the testing for counts is done from the top of cop. Sometimes the cops for testing are taken off the spindles when from half to two-thirds full in order to get more average conditions.

Expanding or "reform" reels to hold a few hanks at a time, are sometimes convenient for holding hank yarn at testing time. By simple screwing round of the centre or arbor the reel will open out or close in to a different size to keep the yarn at tension required.

In dispute cases yarn may be tested for counts in "condition received" and also after a moisture test in "correct condition weight."

Suppose a so-called 60's yarn wraps 59's in "condition received." A moisture test reduces the weight from 100 parts to 98.

$$\text{Then } \frac{58 \times 100}{98} = 59{\cdot}18 \text{ counts in correct condition.}$$

In spinning mills which deliver reeled yarn, the latter may be tested for counts before reeling, possibly checked after reeling.

Tests for counts of doubled yarn more usually indicate the counts after doubling irrespective of shrinkage allowance, but can be for single yarn allowing for the twist.

When yarns have been conditioned, dyed, mercerised, or bleached it is the easiest method to test for counts in finished condition or in "condition received;" it may be troublesome to wash, strip, analyse, dry, or otherwise prepare such yarns to ascertain exact counts as from the spinning machine. Known percentages and conditions help in all matters of this kind.

Judging from personal experience when disputed cases of moisture are submitted to expert tests and decision, the spinner seldom gets the best of it; the tester seems very ready to show the ability of his apparatus and methods to detect added moisture.

Testing for Twist per Inch.

Testing at Spinning Machine.—Managers, overlookers, operative spinners—and their representatives in cases of disputed twist per inch—usually go the mule or ring-frame itself and adopt one or other method of ascertaining the twist from the machine—as distinct from the yarn. Inches delivered from rollers in a given time or for given conditions, and revolutions of spindles in same time (however these may be obtained) form the basis of a twist calculation.

When a spinner, doubler, manufacturer, agent, or other person desires to compare one yarn with another, he must use a twist testing appliance, place the yarn therein, exercise the utmost care and precision in the work, and may then be able to make some progress.

Obtaining the twist per inch in doubled yarns never did present much difficulty, and simple instruments for doing this give quite reliable results and have long been in use.

In testing single yarns for twist there has been greater difficulty owing chiefly to the yarn quickly becoming so soft; it is not always easy to judge the point at which all the twist has just been taken out.

Doubled Yarns.—To test for twist in doubled yarns the appliance is usually made to receive any length up to 12 inches of the thread. Ten inches is a good length to calculate for. A brass-covered foot rule may be mounted flat upon a strong iron base which is secured to a bay-wood base. At one end is a brass or brass-covered pillar or standard containing yarn clips, at the other end the clips or jaws are contained in a movable pillar which can be slided on the base plate to test any length of yarn from 1 inch to 12 inches. These jaws can be quickly revolved by means of a small handle and a wheel purchase which gives four or five revolutions of the thread for one of the hand. Also there is an indicator face which can be easily adjusted to zero at starting any one test.

The yarn can be untwisted, a long needle or pin may be moved along the length of thread to aid in judging exactly when all the twist is out, the operator being possibly helped by a counting or magnifying glass. The indicator will have registered the number of twists extracted and a small calculation gives the twists per inch.

Single Thread Testing.—For single thread testing shorter lengths of yarn must be taken.

A useful example is Heal's twist tester: A small self-contained apparatus mounted on a small hardwood table. On the left fixed jaws, and opposite these are the revolving clips or jaws for the yarn, the two clips being a fixed distance apart of 1 inch, the fixed

clips being neatly arranged so that a small weight may be suspended from each thread to give exact tension before securing.

The handle fits into a small pulley with a wide rim on which are marked left and right-hand figures up to 100. On the spindle is a single worm driving a worm wheel which acts as a second indicator and registers both ways up to 50; it is held in contact with a small spring, so that it can be easily pulled out of gear and re-set to zero. This shows twist per inch up to 50—made for more if ever required—while the handle pulley registers parts of a twist.

The fixed length of 1 inch limits the disadvantage of yarn softening. A small stand below the yarn enables a small plate of black or other colour to show up the yarn more clearly. Fixed also to the wood base is a small stand containing a magnifying glass which can be readily adjusted over the yarn to any extent and in any direction required.

Yarn Examining Machines.

A much used appliance contains clips to hold a black card-board possibly 15 inches long × 9 inches wide.

To test two cops together either presumably of the same make or possibly of rival makes for comparison. Spindles to hold the cops, suitable glass eyes or guides for the yarn from spindle to blackboard. Hand turning of a rope pulley gives about two revolu-

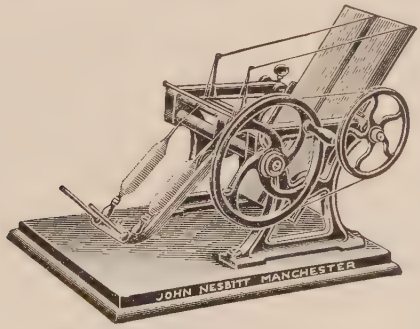


Fig. 118.

tions of card-board for one of handle. The yarn slowly traversed along the blackboard leaving a slight space between each thread.

Shorter blackboards of same width may be used. Cards may easily contain identification marks or numbers for reference, and may either be kept for reference or sent away to a yarn spinners or yarn agents with an indication of such faults as nep, leaf, dirt, snarls, thick or thin places.

Sometimes a much larger machine is used consisting of a cylinder of good diameter and width. A card doffer has been converted before now to this purpose.

A creel to hold possibly a dozen or more cops at one time of same or rival makes for comparison. A traverse motion to lay each thread on cylinder in spiral order.

Cylinder dead black permanent colour, proper guides, and tension arrangements for threads. Power or hand driving. Faults in yarn duly counted and noted.

Leverage in Quadrants used for Testing Strengths and Counts of Yarn.

Take an ordinary lea tester for strength. The weight is secured at a fixed distance from the fulcrum of the weight arm as determined by previous testing and experiment.

In starting a test the weight arm is hanging down in a vertical position so that its acting length as a lever is nil. The pull of the yarn moves the weight upwards along the quadrant, and in this way the resistance to thread pull is increased in proportion to the increase of weight arm leverage.

The markings of pounds increase are close together at the beginning and widely apart towards the end. To increase from 90 to 100 lb.-pull requires a much greater movement of weight lever and clock finger than the increase from 2 to 4 lb., and this is due to the fact that as the weight lever approaches the horizontal position a larger circular movement is needed to give an equal increase in effective weight lever length, the calculations being worked out on the principles of bent levers.

Quite the same principle obtains in the quadrant single thread testers, whether the registration takes place on the quadrant arm itself, or upon a clock face.

Again, the same fundamental principle comes in upon the hank or lea quadrant testers for counts, the marks being so close at the base of the quadrant that it becomes difficult to accurately weigh fine yarns.

Testing the Counts of Yarn from Cloth.

To ascertain the counts of yarn from cloth samples it is necessary to get standard small lengths in sufficient number to give a reasonably correct average result when weighed upon one or other make of small balance constructed for the purpose.

Method 1.—Take three or more groups of possibly twelve short threads each from several parts of the cloth separately. It is all

the better if weft from more than one cop is represented. Cut the groups of threads into very exact short standard lengths, preferably by the aid of small gauges or thin plates of specific dimensions, the yarns being as nearly as possible under working tension.

It should be possible to find total length of yarn; find the total exact weight in grains and make a small calculation to ascertain counts of yarn, i.e. how many hanks there are in 1 lb. or 7,000 grains. If so many grains = so many yards, how many yards will there be in 7,000 grains? Then divide by 840 to bring into hanks or counts.

A templet may be placed on cloth and the cloth marked to templet and afterwards cut. Short threads afterwards abstracted and weighed. In some cases the threads are again laid over the templet after stretching and cut shorter if needed. In other cases threads are definitely extracted of too great length, stretched, and then cut to templet.

Testing counts of yarn from small pieces of cloth requires great care and some skill for precise results.

Ordinary methods of weighing and calculation are available when large pieces of cloth in an unfinished state are available. Each thread may then be from $\frac{1}{2}$ yard to a full yard in length, but quite a number of threads of equal length should be taken.

When only small pieces of cloth are available specially constructed small yarn balances may be used, there being several makes of these, each being accompanied by small plate templets for exact measuring and cutting of cloth before withdrawing the yarn or of the yarn after withdrawal.

In a well-known and much used example the instrument itself only occupies a space of about 3 × 3 inches (in some cases $2\frac{3}{8}$ inches square), and the largest templet about the same space, so that the whole apparatus in its compact box may be readily carried about unnoticed in the coat pocket. An appliance by Messrs. George Thomas is shown in Fig. 120 farther on.

The method of testing is simplicity itself. There may be three templets in a set, the larger one of 3 inches square for cotton with its 840 yard hank, the middle size of worsted and woollen yarn with the 560 yard hank, and the smallest for linen yarn with its 300 yards hank. English counts in each case.

Method to obtain cotton counts from cloth samples of say 4 inches or more square. (1) Cut the cloth exactly to the size of templet. (2) Withdraw a number of threads either warp or weft as required and hang on the hook of the scale or balance. (3) Do this until the scale balances and then the number of threads equals the counts of yarn. Sometimes the yarns are stretched over the templet after leaving the cloth and cut to exact length.

Progress is greater if possibly 80 per cent. or so of the threads

are unravelled and withdrawn at once, and additional threads then added until the scale balances.

If cloth is composed of known proportions of mixed material such as cotton and wool or cotton and linen, a piece may be cut to the size of each templet, and the required number of each kind of thread extracted for the balance.

It is easy to use the instrument for testing counts of yarn from cops or bobbins even when only short lengths are available. In such a case wrap the yarn round the templet to a sufficient extent, cut at both edges of the templet, add or subtract individual threads until a balance is obtained. Always the number of threads represents the counts of yarn.

When dyed or bleached yarns are tested for counts by any method it must be remembered that bleaching makes yarn finer by possibly 5 per cent. or more, while dyeing makes yarn coarser to the extent of 2 to 5 per cent. for fine colours, 5 to 10 per cent. for medium colours, 10 to 20 per cent. for dark colours. Example: cotton yarns dyed grey or medium colour might be 30's dyed and 33's before dyeing; 30's spun yarn might become 31½ after bleaching. These factors must be allowed for in judging the grey yarn counts from printed, dyed or sized cloth samples since sizing and printing operate the same way as dyeing. If warp yarn has been sized 20 per cent., then extracted warp threads showing 24's would have been more like 30's before sizing.

Shrinkage due to waviness of yarn owing to intersection and bending round each other of warp and weft threads, may affect the exactness of counts when tested by small balances, especially in closely woven cloths. The tendency will be for extracted threads to weigh heavier or coarser due to the crimping effect.

In fine cloth this effect may be ignored. In some others a percentage may be allowed according to experience. Twenty-nine threads for example might be taken to represent 30's yarn instead of requiring thirty threads on the balance hooks.

In cases of sized cloths the sample may sometimes be well washed and then dried before testing, but it is not always easy to tell when all external filling has been removed. By proportioning number of threads weighed to variations in length of hank for cotton, wool, or linen, sometimes the templet for one material may serve for a different one.

For counts of cotton yarn 100's to 200's, a steel wire hairpin or reduction hook is occasionally used, which is placed on the hook and represents perhaps 80 per cent. of the number of threads required, leaving only a few threads to be added to get a balance: e.g. reduction hook or hairpin represents eighty-five threads. sixteen are added to get a balance, then 101's will be yarn counts.

Per contra a person may desire to use a piece of cloth double

the size of the templet, and in that case a small brass wire, called a "doubling hook" may be hung on the opposite side of balance from the threads, and then proceed as before.

In another appliance a fixed length of yarn may be taken, as for instance 60 inches in every case, and a small pointer is moved along the opposite arm of balance until a balance is established, and the pointer comes opposite to the counts in scale.

In some cases of testing yarns from small cloth patterns, a quantity of threads are cut to an equal and previously fixed length, and weighed against a fixed weight so that again the number of threads equals the counts of yarn. In spinning, weaving, and doubling mills, and in yarn agent's offices, when cops, bobbins, hanks, and cheeses of yarn are available, the full size wrap reel and lea lengths of yarn are used to find counts and this method is the best known, simplest, and, generally speaking, the most reliable.

The small pocket balances have the two great and special uses of (1) adaptability to short lengths of yarn ; (2) pocket appliances which may be used almost anywhere.

One method for short lengths is to twist the yarn to be tested against a yarn of known count, and confirm by weighing if necessary. This method is more used by persons on the weaving side, than on the spinning side.

In cases of designers or others who may be often required to determine counts from small pieces of cloth, it is a good thing to keep a range of cloth pieces at hand, of which the yarn counts are known. From this range select the nearest alike and this will be a good guide with the sample. The cloths should be nearly alike in colour, picks per inch, ends per inch, weave, sizing, and finish.

Suppose we think the yarn in submitted cloth samples is about 30's, then take thirty short threads and compare by twisting with thirty threads of the known cloth, linking the two sets of threads together and twist by hand. Add or remove threads of the unknown counts until equal thickness is obtained and then count the threads for the counts. As stated in the small balances for testing counts from small lengths of yarn the templet cut lengths in one method are put in stated numbers on the hook or pan of a quadrant balance and the quadrant pointer indicates the counts on the scale, whether it be 20's, 24's, 30's, or other counts.

In a second method instead of an equal number of templet threads weighing against a varying pointer, the threads vary in number until they equal a fixed weight. Twenty-four threads means 24's counts. Method I. means equal threads and varying index. Method II. means an equal index or register and a varying number of threads.

Light weights and levers mostly in use for this work, but sometimes delicate spring balances.

Testing should be done by precise persons, using reliable instruments of precision, who should not be over-hurried in their work; business conditions, however, often insist on celerity in testing as in other things.

Templet or small balance testing is best done by careful persons as it may easily give errors due to :—

(*a*) Want of uniformity in yarn tension.
(*b*) Very close marking of the scales or indicators.
(*c*) Very small quantity of yarn tested.
(*d*) Possible waviness or curl of yarn.
(*e*) Want of exactness in cutting to templet.

Whether in testing counts or strength of yarn, large percentage variations are much more likely to occur in testing small lengths, the same person getting 15 per cent. variation from the short length against only 5 per cent. in the more common lea test.

For precise measurement of yarn sometimes a flat rule or board of 3 to 6 feet long properly marked in inches and half inches proves as good as anything and permits of stretch and tension.

In testing templet lengths of weft yarn from cloth it is best to take bunches of about two dozen threads from different parts of the cloth, to get at different weft cops.

In order to guarantee accuracy in testing counts of weft yarn in dispute cases samples of cloth 2 or 3 yards long are desirable so that weft from different cops may be got. Apart from disputes the samples need only be a few inches square for ordinary students or designers' purposes.

Portions of headings in cloth are somewhat unreliable for weft testings. Variations in counts of weft are frequently obtained from different parts of the same cloth. In the case of warp each thread represents a different cop so that any test will represent many cops rather than one, and ordinary pieces of cloth only a few inches square should do, while a yard is deemed long enough even in a dispute case for warp.

Scouring all cloths is considered the only way of taking away all extraneous matter such as size, chloride of magnesium, or some dyes.

Variations in Counts.

Percentage variation in yarn counts is naturally greater in some cases than others. The writer has known 100's to show 110's and 30's to wrap 32's at good firms, but 2 to 4 per cent. is more like an acceptable variation, and should be less in coarse than in fine counts. Condenser and preparation yarn sometimes show a still greater variation. Yarn should not be condemned simply because occasional wrappings show extreme variation. For cotton yarns

one writer quotes results from certain tests as follows : 1's to 10's = 2½ per cent. ; condenser yarns = 4 per cent. ; 11's to 20's = 2 per cent. ; 21's to 40's = 2½ per cent. ; 41's to 60's = 3 per cent. If these represent mean variations from lowest to highest they are perhaps not so bad. Condenser yarns with defective condensers and unskilful waste mixings often show very much greater variations. So also do fine counts if every precaution is not observed first to last. It stands to reason that least variation would show from weighing four leas together, more from one lea weighings, and much more from short lengths.

Variations in counts should be stated in percentage and not in counts in order to obtain a fair basis, in cases of dispute.

If 100's yarn wrapped 103's it would only be 3 per cent. too fine ; but if 10's wrapped 13's it would be 30 per cent. fine.

Small Pieces of Yarn for Counts.

We have described two or three methods of ascertaining counts of yarn from small lengths extracted from pieces of cloth.

Counts of yarn always mean a certain adopted standard relation between weight and length, this being for cotton a hank = 840 yards and hanks per lb. equal the counts.

If 1 hank of 840 yards = 1 lb. the count is 1's.
If 10 hanks „ „ = „ „ „ „ 10's.
If 100 „ „ „ = „ „ „ „ 100's.

It follows that if the correct length and weight of any small or large portion of yarn be ascertained, a little proportional arithmetic will determine the counts.

Correct weighting, correct measuring, and correct calculations are all that are needed.

For this reason in matching cloth from small samples, some individuals prefer to use no instrument save a fine balance and fine weights to weigh at least as fine as $\frac{1}{50}$th of a grain and possibly $\frac{1}{100}$th part. Such balances as used by analytical chemists are readily to be obtained.

Any kind of convenient rule, templet, or gauge may be used for measuring.

Any advanced student can make the calculations. The same balances will be serviceable for weighing any small thing, such as small pieces of cloth.

Elaborate calculations can easily be made showing how much short length of yarn a weaving firm would get if counts were received by them distinctly too coarse although the correct weight of yarn was delivered. In a delivery of 20,000 lb. of 22's yarn of true counts, there would be 440,000 yards of yarn. If this yarn

were 20's there would only be 400,000 yards. This would affect the length of cloth woven from the 20,000 lb. of yarn.

To allow for conditioning it is sometimes the custom to spin yarn about 4 per cent. too fine, e.g. spin 52's to sell as 50's, but paying the self-actor minder for spinning 52's.

Larger sized draft change wheels, sometimes using the crown wheel as a change wheel and cutting the draft wheels to 18's diametral pitch instead of using 12's diametral pitch as formerly, have enabled greater exactness in counts to be produced.

Moisture.

Ovens.—Many cotton, spinning, doubling, and weaving firms—but by no means all—regularly use ovens for testing small quantities of raw cotton or spun yarn.

Gas, electricity, or steam may be used for oven heating, as desired. Electrical testing ovens for schools have gained in favour.

Steam has generally been considered a suitable heating agent for a cotton mill because of its use for heating or driving the mill, and this favours steam for other purposes.

At one Bolton firm, for example, a steam-heated oven is used fitted with an indicator or thermometer arrangement, and can be set at 212° to 221° F., material put inside, a sufficiently uniform temperature guaranteed, oven left for 40 to 60 minutes. The cotton is left in oven until it ceases to lose, and scorching of cotton gives very little trouble. To test cops from the cellar they pull them to pieces from the cop bottom end.

Regain Standard.—The loss is normally found to be 1 to 1½ per cent. above the natural regain standard or 100 parts regaining 8½ or 108½, losing 8½.

This regain of 100 parts of absolutely dry cotton becoming 108½ by exposure to the air or ordinary atmosphere has been accepted for cotton for many years. If 108½ parts contain 8½, then 100 would contain 7·834 so that the standard of moisture is 7·834 per cent., or 100 parts contains 7·834 parts of natural moisture, with what might be termed an average condition of the air. This applies to both cotton and yarn.

Regains for other textiles have been given as follows: 13¾ per cent. for jute, 12 per cent. for flax and hemp, 17 per cent. carded woollen yarn, 18¼ per cent. for worsted.

The drying temperature to be 212° to 230° F. or 104° to 110° C.

Size of Sample.—In testing for moisture by an oven a sufficient amount of yarn should be taken, and the Manchester testing house require a minimum of 1 lb., and condemn wrapping up of the samples in paper parcels which permit variation in transit, requiring the use of proper air-tight tin cases which they supply if desired.

Separate samples in separate tins, raw cotton samples preferred about 3 lb., with a minimum of 1 lb.

Oven Conditions.—In the mill the case or skip of yarn should be first weighed to see if it agrees with spinner's delivery note. Grain weights or gramme weights used in testing. Yarn to be weighed only when in the cage or oven both before and after exposure and weights booked down. Sometimes the oven is hot to start with, but in some cases a cool oven is required to start the test.

Either for steam, gas or electrical heating it is best for the oven cage containing the sample to swing loose in the oven, and the cotton or yarn not at all in contact with the oven itself for fear of scorching—a defect which more especially needs guarding against with gas oven testing. Exposure until no more lightening or loss occurs, the time varying with amount of moisture and temperature of oven, but every tester should fix a standard for himself within limits.

Old-Style Ovens.—Moisture tests are exceedingly important, and can now be carried out with quite reasonable accuracy by means of special testing ovens.

Some ovens used for the purpose about 1898 required the samples to be weighed before placing in the oven and again after taking out. This method soon gave way to that of using ovens in which both initial and final weighings are done while the samples are in the oven all the time. This removes the danger of samples regaining moisture after leaving the oven and before weighing.

Creel Exposure.—Both raw cotton and spun yarn may be tested for moisture. Many firms are without testing ovens, but can always get a good idea of commercial condition of cotton or yarn in regard to moisture by exposing samples in a more or less open condition in warm places such as on mule creels or possibly near economisers. Such tests of course give different results from oven tests which latter drive out natural moisture as well as added moisture and do the work in from 50 to 110 minutes as against perhaps 24 hours when placed on a mule creel.

Humid Testing Room.—A really good textile laboratory should be regulated to a required degree of humidity as the relative humidity of a room may affect both counts and strength of yarn.

It is quite an established fact that a conditioned yarn is likely to weave or wind better than a yarn taken directly from mule or ring spindles, and it is also well understood that a large proportion of cotton yarn is definitely put through a conditioning process. The weight, length, and counts of yarn are so much affected by conditioning, and the amount of conditioning may extend to such commercial limits, that great scope exists for differences between spinners and users of yarns.

Benefits of Conditioning.—As far back as 1880 the present writer

regularly saw operative weavers conditioning their own weft in the mill yard at the well, and in some respects it would be better now if users instead of spinners did the conditioning.

Conditioned yarn or cloth, tested in a humid atmosphere practically always shows a higher breaking strength than in under dryer conditions, and conditioned yarn wraps coarser than unconditioned. Cloth strength is perhaps even more affected than single yarn strength by humidity.

Yarn spun in a humid or humidified spinning room will contain more moisture than if spun in drier conditions, both being tested promptly, and both quoted as in a dry or natural condition, the variation being possibly from 3 to 7 per cent.

Well-conditioned yarn stocked in some places, may develop mildew, and the writer has often known yarn left for a long time in a cellar to become unworkably weak.

Difficulties in regard to moisture standards being adopted are enhanced by the fact that spinners want standards applying to raw cotton as well as to spun yarn.

Regain.—The 8½ per cent. "regain" is based upon an "average" condition of the air, but several circumstances affect the air condition. Some makers and users of cotton yarn have mutually agreed to accept the 8½ per cent. "regain," but this can scarcely be said of raw cotton. Dispute cases carried to law have been settled on the 8½ per cent. "regain" when no special condition *re* moisture has been in the contract.

Effect of Oven Tests.—Oven testing of yarn is detrimental to its suppleness, strength, elasticity, and colour, but the small size of samples taken makes this matter perhaps of no great consequence. Ovens of higher or lower temperatures have both done this. 180° F. was adopted in some former ovens, but 212° F. is now prevalent in England. Ovens are fitted with thermometers which register much higher than this, and every effort should be made to keep the temperature uniform, when once attained, whether the heating medium be gas, steam or electricity.

Higher the temperature and shorter the period of exposure, and exposure depends to some extent upon the density and size of the sample, exposure being continued until the samples practically cease to lose weight, and from 40 to 60 minutes at 212° F. being perhaps sufficient, as against possibly 120 to 130 minutes in old style oven at 160° F. After oven testing yarn exposed to natural air conditions may regain possibly 3 per cent. in 3 minutes. Scorching of samples is to be avoided. Duration of exposure has varied a good deal by different people.

Raw Cotton.—In oven tests for raw cotton care is required to obtain fair samples, one method being to take a number of cones or wedges of cotton from outside to centre of bale, the cone base

outside, 3 lb. samples enclosed in air-tight cases being preferable. Irrespective of shape of sample it is usually preferable to make it up in pieces from different parts of the bale. Separate samples in different tins.

Spinners' Tests.—It has been argued that spinners might profitably make occasional moisture tests of their yarn direct from mules or ring-frames, with a view of deciding the amount of conditioning required. It is doubtful if many spinners do this.

Textiles in any form are hygroscopic, or will absorb moisture from the atmosphere in proportion to the humidity thereof.

Assuming the natural moisture of cotton to be approximately $7\frac{1}{5}$ per cent., and drying this out in an oven, subsequent natural exposure would regain this. There is no particular trouble in getting raw cotton, cotton yarn, or cotton cloth to absorb 5 to 8 per cent. added moisture extra to the above natural amount, by modern conditioning methods.

Regains.

When any standards are required in dispute or other cases they are mostly based on the table below :—

	Regain.	Per cent. loss.
Cotton . . .	$8\frac{1}{2}$ per cent.	7·834
Jute	$13\frac{3}{4}$,, ,,	12·09
Flax and Hemp . .	12 ,, ,,	10·71
Silk	11 ,, ,,	9·91

Conditioning of Cotton Yarn: Effect on Strength, Counts, and Elasticity.

Generally speaking the careful and skilful conditioning of cotton yarn improves its working at the immediately succeeding processes. By far the most important of the features of yarn above specified is that of strength, and this rises within limits according to the amount of water added, so that 5 to 7 or 8 per cent. of added moisture may increase the strength per lea of 40's to 60's yarn from 1 to $2\frac{1}{2}$ lb. or so. Each one of the properties is more or less related to the others, and the increased flexibility of the yarn due to moisture helps the fibres to bend round each other more easily, and to increase the strength by increasing the "coil" friction of the fibres. The elasticity or stretch of cotton yarns is slightly increased by conditioning partly owing to the shrinkage which takes place when the thread absorbs the moisture, since it is well known that 50's to 60's yarn will become about two counts coarser by average conditioning; the increased flexibility also helps in giving increased elasticity. The term resiliency is not often used in connection with

cotton yarns, but since it practically means capacity for springing back or rebounding to the touch, it may be taken to be comprised in the terms flexibility and elasticity.

There are now quite a number of methods more or less in use for conditioning cotton yarn, the tendency of recent years having been towards devices for expediting the process on the one hand, or increasing the conditioning effect on the other hand. For many years the very general method was simply to expose the skips of cops in a conditioning cellar for something like a week, and simply to allow the yarn to absorb moisture in a natural manner ; and this practice is still largely in vogue, the cellars being often equipped with humidifiers. Sometimes the yarn is watered with a degging can, and sometimes by special hose-pipes fitted with spraying nozzles, care being taken to keep the water clean. Dipping the skips, tins, or cages of yarn into a water tank, and winding damp cloths round layers of cops are two of the quickest methods of conditioning yarn. Each firm adopts that method deemed to be most convenient or suitable to its requirements, or that which their workmen have become accustomed to.

Raw Cotton. Small Sample Testing in Mills.

Instead of 20 to 40 lb. mill test, the size of sample for testing may be reduced in fine spinning mills, and about 2 to 4 lb. weight taken as a minimum.

First samples may be duplicated in samples of a few pounds each to prevent loss in carrying about, but under ordinary circumstances a 2-lb. to 4-lb. sample may permit of a test in the mill.

We may start test at *scutcher* after most accurate weighing, and spread equally on feed lattice with machine stopped, and lattice length marked out for weight of sample, to get correct counts at every later process.

Cards are stripped about three times daily, so the small samples may be carded mid-way between stripping times, to get average results in strips and cleaning.

Loss in weight of cotton to be recorded as waste, without attempting to collect and weigh the waste of such small samples. Be extra careful at all machines.

At comber pass the small samples all through the same head. Make small portions into six or eight cans or enough for draw-frame, and pass through all three heads. Make enough finisher draw-frame cans for thirty-two cans testing into thirty-two bobbins at slubber ; small lengths only.

This allows sixteen small bobbins at intermediate, eight at roving frame and four cops at mule, with test bobbins creeled after full diameter of cop has been reached. Fine jack not used.

Fibres in Cross-Section of Yarn, Roving or Lap.

Having obtained a constant from number of fibres in cross-section already known, we can ascertain any given hank of yarn, roving or lap by the following formula:—

The square of diameter × ·7854 = area of circle.

The diameter of yarn, roving, or of circle made by the rolling up of a lap, varies inversely as the square root of the counts.

·7854 × hank and answer divided into constant 3168 (for Sakel or other cottons with the same diameter of fibre), will give the number of fibres in cross-section. This constant is derived from multiplying ·7854 by fibres in cross-section of yarn already ascertained, and multiplying the answer by the same counts.

In order to get as nearly correct as possible there have been in one experiment twelve different counts of yarn taken, varying from 40's to 175's, and the average or mean obtained from these.

Examples.—1. Wanted the number of fibres in cross-section of 40's—

$$\cdot 7854 \times 40 = 31 \cdot 4160,$$
$$3168 \div 31 \cdot 416 = 100 \cdot 8.$$

By microscopic examination of ten sections the average was 100·2 for 40's.

2. Wanted, the number of fibres in cross-section of comber lap of 20 dwts. per yard.

(*a*) $\dfrac{7000 \text{ grains} = \text{grains per lb.}}{20 \text{ dwts.} \times 24 \text{ grs.} = \text{grains per lb.}} = 14 \cdot 58$ grains per lb

(*b*) $14 \cdot 58 \div 84 = \cdot 017$ hank of lap

(*c*) $\dfrac{3168}{\cdot 7854 \times \cdot 017} = 237{,}271$ fibres in cross-section of lap

(*d*) Lap 11·5 inch wide $\dfrac{237{,}271}{11 \cdot 5} = 20{,}632$ fibres per inch of lap.

Such calculations are perhaps more interesting than practically useful. (See pages 520-525.)

Machine Testing.

Mule.—Many tests of complete draws of self-acting mules reveal the fact that every time a mule carriage starts from the roller beam, and the spindles begin to twist the yarn, the driving power momentarily becomes very great, then quickly settles down to a steady drive until ready for backing-off, at which time the power curve drops down very low, rising a few points for drawing-in, and

becoming almost nil for the last short portion of each run-in owing to momentum previously obtained.

Proportionate power requirements are approximately as follows for a complete draw :—

Starting out—22 parts, steady running out 15 parts, backing-off $\frac{3}{4}$ to $\frac{7}{8}$ of a part, running up 4 parts, finish of run in almost nil or $\frac{1}{4}$ part.

A spinner knows his top belts break most at starting out of mule, and that a slack belt swings or jumps about most at start out.

Roving Frame.—The extreme length of fly-frame spindles, the heavy flyer suspended from the top of each spindle, the great length of the upper bearing or collar—especially the long collar—make it very advisable to have spindles, collars, and lifter accurately set. A heavy running frame may reveal itself in belt breakages, reduced production, and slip of cone belt.

Frequently the driving power required is greater at one part of the lifter traverse than another, and especially if the lifter is loaded by binding of collars, spindles, and lifter racks. Actual tests reveal the fact that any such variations are perhaps more likely to show up when the lifter is in its lowest position, owing probably to the shorter space between upper and lower spindle bearings causing one to fight more against the other. Power tests reveal the fact that the driving power of a bobbin and fly-frame is very much higher at start of a set of bobbins than afterwards, especially for bobbin lead ; starting at a maximum for a new set of bobbins the power required rapidly diminishes as the diameter of the lower cone increases, and the speed of the bobbins and lifter diminish.

With the cone belt moved about one-quarter of its full lateral traverse the rate of diminishing power is more gradual, the power diagram roughly following the outline of the cone drum.

In a certain power test of a roving frame for division of power :—

Drafting the cotton	=	4·70 per cent.
Driving the draft rollers	=	7·84 ,, ,,
,, ,, lifter	=	2·36 ,, ,,
,, ,, bobbins	=	33·12 ,, ,,
,, ,, spindles	=	51·98 ,, ,,
		100·00 per cent.

Dynamometer.—Such an instrument as indicated in Fig. 119 is a sort of scale for weighing or measuring power.

The power running through such an instrument for the time being, may be said in a sense to be weighed on the principle of the "Platform" weighing machine.

It is convenient if the apparatus can be attached to the end of a driving shaft of machine to be power tested.

There are two pins for driving engaging with the loose pulley of the machine.

The apparatus being fastened to the shaft, the belt being on the loose pulley, the power must run through the power tester. Lever connections are used to indicate the power on a suitable dial in pounds.

The same apparatus may possibly be used to test either the total power of a machine, or the power required for a sectional part of the machine.

Tachometer (Fig. 121).—An ordinary plain speed indicator may indicate revolutions made during a time limit checked on a stop watch. The tachometer proper dispenses with the watch and shows the rate of revolutions per minute directly on its face. It is

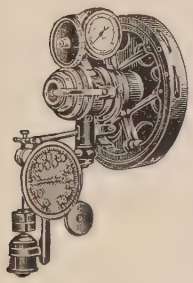


Fig. 119.

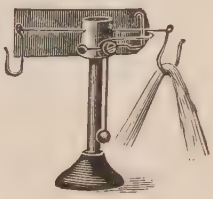


Fig. 120.

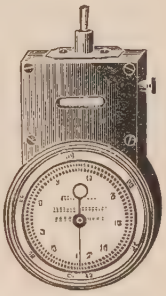


Fig. 121.

the author's experience that some of the tachometers are best handled and used carefully. A tachometer may be lightly held against the centred end of a rim shaft, tin roller end, or, generally speaking, shaft end of any machine in the mill, perhaps finding its greatest vogue in quick running parts. Spindles of mules, ring-frames or fly-frames are included in parts suitable for speed testing. In some examples, amount of pressure decides range of speeds under test. One instrument may serve for different ranges of speeds, and, when convenient, may be locked in position for a given speed range. Light pressure against a shaft may sometimes serve without centre hole.

Small Counts Balance (Fig. 120).—For testing the counts of yarn taken from small pieces of cloth. Templets are supplied so that definite thread lengths may be quickly and accurately cut.

The number of short threads required to give a balance represents the yarn counts.

A counterpoise is used to the pendulum so that a horizontal position may be obtained even if the main pillar is not rigidly vertical, and this helps in getting a balance of the wire beam when the yarn is placed thereon.

There are various small balances obtainable for helping to find the counts of short lengths of yarn.

Test Results from Using Waste in Mixings.

Lap ends, sliver, and bobbin waste are the more usual kinds of waste returned to the mixings, the latter being now usually passed through a roving waste opener before going back to the mixing. Sometimes comber waste and even strippings of a superior cotton are cleaned and returned to the mixings for lower classes and counts of yarns.

The use of an excessive amount of waste is conducive to lap licking, roller licking, breakage of slivers at card and draw-frame, excessive breakage of ends at the fly-frames and spinning machines, and finally weak, irregular yarn. Extra twist must be put in at the fly-frames and spinning machines, accompanied by reduced production and greater cost of production. There will be excessive waste loss at the various machines and especially the earlier ones. The proportionate degree of these evils will depend upon the proportion and quality of the waste, the fineness of the counts, and the cleanliness and suitability of the waste for the kinds of yarn being spun.

Variation in Tests of Card Slivers.

It is very often the lap that is faulty, and we might first direct our attention to this point. As a rule the fault in the lap would be fairly apparent, but reference could easily be made to the weighings of full scutcher laps usually written down in the blow-room. If these appeared sufficiently correct a personal check might be kept for a time upon these weighings. It would, however, be quite possible for the weight of a full lap to be correct and yet short lengths of the lap to be quite variable, and a lap could be unrolled, examined, and 2-yard lengths carefully broken off and weighed. These coming out erratically we should turn our attention at once to the various parts of the piano feed regulating motion, and see that the cone belt was sufficiently tight, the various rods and levers clean, free, and properly adjusted. Such work might be carried out both for scutchers and openers, and in connection with the latter the various mechanisms and actions of the hopper feeder could be carefully examined. At the card itself a check could be placed on the stripping, grinding, setting, and condition of the principal organs and likely details.

Testing or Judging the Quality of Carding.

The index of the quality of the carding is found in the thin fleece or web of cotton delivered from the doffer; and an examination of this web affords a more rapid and more accurate judgment of the quality of the work done by the machine than can be equalled on other machines in cotton spinning. Any carder, manager, or other person in charge naturally looks at the web in order to judge the work whenever he may be looking at any card. Merely looking at the web without disturbing it is often sufficient, but the customary plan is to lift a narrow piece of the web up for a length of 20 inches or so, break this off, and hold in a good light, and if need be projecting it against a black surface. This may be done without stopping the card and without appreciably affecting the quality of the work. The examination may be primarily made in order to discover whether such defects are present as very small motes, portions of leaf, thick and thin places, specks of any undesirable matter, clearness of web, or its freedom from cloudiness, or nep. The selvedges of the web may be noted without taking any of the web from the card. Naturally the lap of cotton fed to the machine will be examined first of all if any particular defect is present to an unduly large extent.

For example, in the case of neppy webs, some classes of cotton are more naturally inclined to this defect than others. In the case of certain cards coming within the observation of the present writer a great deal of trouble is experienced with nep, and the fault is known to be due to a good deal of comber waste being mixed with the fresh cotton, and the nep is therefore present in the laps given to the card. A somewhat curious feature of a card is that it is either able to extract neps or to make them. If the laps are exceedingly neppy it is hardly competent for a carding engine to absolutely remedy the evil, however well the machine may be attended to in every direction. If the lap is proved to be practically free from nep, and yet the delivered web is neppy, it is clear that something is distinctly wrong with the machine. A possible cause of nep is the rolling and rubbing up of the fibre between two contact surfaces set too closely together. The presence of such defects may lead to greater attention being given to the questions of stripping, grinding, and setting, and in general to getting the card in the best working condition, after which the nep will probably disappear if the lap is practically free therefrom. It need hardly be added that neps are very small balls of rolled or curled up fibre, and badly ground cards, used up wire, reckless and irregular settings are possible causes.

CHAPTER XI.

MILL AND MACHINERY DRIVING IN COTTON MILLS.

Testing. Electrical Driving.

With electrical driving, power can be transmitted in any direction without using the lines of shafting which make belt, wheel, or rope drives somewhat rigid.

Even with "group" driving by motors it is easy to sectionalise the machinery so that one part may stop while others work on, without necessarily running all the shafting just for one section.

In the case of self-actor mules and twiners, the driving loads vary so much in every complete draw—four to five draws per minute for American cotton and three to four draws per minute for Egyptian cotton—that three pairs of mules should be preferably the minimum for one motor, so that a balance of driving power is likely to be maintained. Even then the motor should be well able to bear the possible high loads due to two or more mules starting from the beam at the same moment. In a particular example of a forty horse motor placed on somewhat weak floor complete steadiness was obtained by linking the top of the motor to an adjacent wall by iron bars.

Motors may be mounted on the walls, on the ceiling, on the line shafts themselves—the weight of course taken by separately supported bearings—on special stands, on the floor, or even become part of the machine in the case of a ring-spinning or ring-doubling frame with the motor directly coupled up to the tin roller shaft.

At the time of writing, a motor has been suspended for many years, upside down, from the ceiling of the spinning room at the Bolton Technical School and there has never been any trouble with it.

Modern equipments of motor driving usually have 3-phase alternating current (A.C.), experience having proved this to be better than direct current (D.C.), for both motors themselves and also for the current transmission.

Cotton chiefly forms the insulation for the motor windings, coated with suitable composition such as shellac varnish.

Cleanliness and coolness are valuable features for keeping motors in good condition.

The important duty of fuses is to cut off the current in the event of overloading, over quick starting of machines or shafting. Fuses may be regarded as safety valves which go off so as to prevent more serious damage. Fuses should be very accessible for renewal, and attendants should be careful about making the fuses too strong with a view to saving a little labour in renewals. That way lies great danger and possible expense.

The following is a brief description of a change from bevel gear drive to electrical motor drive carried out in 1921 by the author's son, Mr. Wilfred Thornley, at a Mossley Mill.

This mill was formerly driven by an old type of compound engine situated at a long distance from the boiler (the steam pressure being reduced to suit the engine) through a complicated series of bevel wheels, spur wheel, and large lengths of shafting at various angles.

This system has now been entirely scrapped, and five motors have been installed to drive the various departments. In the new electrical drive four of the five motors are placed upon brick pedestals so as to bring the shaft of the motors central with the line shaft. The two are then connected by flexible couplings. This dispenses with belts or ropes and their attendant upkeep, in addition to eliminating all slippage. The remaining 200 horse power motor drives the spinning mules by means of ropes. The mule-room is a three-storey building, and difficulty was experienced with the direct drive. It was not commercially advisable to place a motor on each floor on account of the number of mules in the rooms. A mill which has many mules on one floor would find the direct drive simple to install.

The electrical energy passes through the main cables at 6,000 volts. This is reduced by two transformers into 400 volts. The switch-board contains six switches, amperes, and kilowatts registering metres. Provision is made for running on one transformer only if on light loads. From the switch-board the wires are conducted to their separate motors, either through steel tubing or lead-covered cables. All the motors are 3 phase, 40 periods, and 400 volts.

The motors are of necessity "slow speed" in order to be coupled direct on shafts, and at the same time prevent excessive shaft speed. The revolutions per minute of the motor coupled to the line shaft in the card-room are 336, and it is 150 horse power. The motor for driving the bottom ring room is the same in all respects. The flexible couplings used to connect the motors and line shafts consist in each case of a pair of flange couplings, the half fitting on the line shaft having six holes drilled in it sufficiently large to permit a pin to fit loosely in each. On each of the six pins is placed a rubber ring to take up the slackness and yet permit successful running

even if the shafts get slightly out of line. The other half of the coupling, containing the steel pins, is secured on the motor shaft by means of a feather bed-key, and can be moved along the shaft and key easily to renew the rubber, and is held in position by a set screw. (See pages 539-540.)

The small figures represent the different halves of coupling and one of the rubbers respectively.

The blowing-room is driven by a 75 horse-power motor running 480 r.p.m., as is also the small ring-room. To hold the latter motor it was found necessary to build a pedestal of cement, 11 feet high.

In addition to economy in friction there is also a tremendous saving in oil, as all the motors are of the slip ring oil type, and the oil requires very little renewing. The remaining two motors and their line shafts run at 480 r.p.m., which is as quick as is recommended for line shafts. There is real saving in shafting friction and more uniform driving.

Comparative Strengths of Cotton Fibres and Cotton Yarn.

It has often been contended that strengths of cotton yarn are not nearly so good as they should be when the comparisons are made between strengths of individual fibres, number of fibres in a cross-section of yarn spun from such cottons, and strengths of such yarns as disclosed by the lea tester. On this point the writer appends the following notes :—

1. It does not pay the average spinning mill to seek yarn strength at considerably increased cost.

2. When it does pay a cotton mill to seek yarn strength almost regardless of cost, then results much better than average are obtained.

3. Recently an old student of the writer's—now a head carder—went by request to a mill in another county to investigate possible causes of inferior yarn strength. For 60's carded twist the yarn was found to pull 27½ lb. per lea. The same cotton brought to the carder's own mill pulled 33 lb. for 60's carded. Really good combed 60's twist from much the same cotton was found to pull 40 lb. and more.

4. It would appear that misconceptions on this point of proportionate strengths of cotton fibres and yarn have arisen owing to two somewhat erroneous ideas prevalent for many years.

In the first place the number of cross fibres per cross-section of yarn has usually been much lower than given in tables some years ago.

Mr. Sewell—for some time an evening assistant of the present author's and now manager of an important Bolton mill—has for years conducted extremely careful microscopical investigations in

regard to twists in Sakel cotton fibres and in regard to number of fibres per cross-section of yarn. Invariably such investigations—a few of them checked by the present writer—have disclosed the fact that cross-sections of the yarns examined, have contained nothing like the number of fibres quoted in some long-established tables.

Some of the results are given in another page of this treatise. Instead of 20 to 30 per cent. Sewell's tests show more like 60 per cent. of fibre strength utilised in yarns.

5. It does not appear that lea testing for strength has flattered the yarns in the way of revealing their full maximum strengths.

Since increased attention has been given to single thread testing it has been found that careful and precise operation of single thread testing reveals an aggregate strength for 160 threads greater than that shown when the same yarn is lea tested. Eighty threads or wraps from the 54 inches wrap reel give 160 or 80 on either side, at the lea tester. More recent methods of testing fibre strength ought to be better than those of thirty years ago.

Cotton spinning is a useful and commercial business rather than a lay-out for the purpose of producing specific effects totally regardless of cost and amount of yarn produced. Another careful investigator has placed the fibres per cross-section at 94 against 160 quoted by Dr. Bowman.

There is certainly room for the Shirley Institute to proceed with such investigations as number of fibres per cross-section of yarn, strengths of individual cotton fibres, maximum strengths obtainable in cotton yarns when the very best conditions are obtained in regard to mild, slow, opening, cleaning, and carding, double and treble combing, most suitable drafts and twists, best conditions of atmosphere, most careful and skilful operatives, best possible cottons for the work, effects of subsequent treatment as gassing, mercerising, sericising, schreinering, bleaching and dyeing; and a host of other allied problems.

It has been estimated by several authorities that the full tensile strength of cotton fibres is not realised in the produced yarns, say only about 20 to 30 per cent., two-folds showing up better than singles.

It is also stated that yarn breaks because of the slipping of fibres one over another rather than because of fibre rupture; also that strength of yarn depends more upon amount and proportion of spinning or doubling twist rather than upon individual fibre resistance.

Previous to 1900 the present writer found that soft brown Egyptian cotton gave increasing strength to the yarn as the twist constant was increased from the standard 3·606 up to about 5, other things being equal. The celebrated and dominant Sakel cotton of recent years has quite confounded such tests, maximum strengths

having been obtained with lower than four constant, and many firms finding it best to spin 60's twist with one or two turns per inch lower than standard.

6. *Gassing* or singeing is one of the most curious methods of treating either yarn or cloth, and has often given rise to the query as to possible damage to yarn and reduction of yarn strength. Variations in types of burner, mixtures of gas and air, strength and purity of gas, speeds of machines, the question of electrical singeing, etc., have kept such questions very much alive. Experience and observation all favour the conclusion that inefficient or careless gassing will injure the yarn; but that gassing under the best conditions actually strengthens the yarn, taking count for count. Mr. Dodson of Bolton, about 1904, gave test results proving this, as did also a lecture given before the Cotton Managers' and Overlookers' Association thirty years ago. Efficient gassing only burns away the loose fibre ends of the yarn which add weight without adding strength, so that the best gassing makes the yarn possibly about 5 to 6 per cent. finer, and might produce a 120's/2 gassed yarn from a 114's/2 plain yarn, with the 120's/2 having as much strength as the 114's/2. Later tests have confirmed the foregoing. It would appear that the slight amount of cotton wax in the fibre will be softened by the singeing and help to consolidate the yarn. Naturally the general character of the yarn affects any such results as the foregoing.

7. In regard to the effects of mercerising upon cotton yarns it has been generally agreed by investigators that this process usually adds very considerably to the tensile strength of the cotton thread, as much as 30 per cent. to 50 per cent. being referred to, but results vary, as also in bleaching.

Cotton fibres submitted to this process are stated to shrink in length and increase in diameter 20 to 30 per cent.

The yarn shrinkage appears to give greater cohesion among the fibres, and the removal of cotton wax appears to diminish slip among the cotton fibres.

It has been given as possible for the diameter of a cotton yarn mercerised under tension to diminish, while the diameters of individual fibres increases.

Dr. Balls, Dr. Bowman, Professor Midgeley, Dr. Matthews, Messrs. Knecht, Hall and O'Neill, are some of the important men associated with such investigations as the foregoing.

Bleaching is one of the oldest and most used treatment to which cotton yarns and cloths are subjected and which may greatly affect yarn strengths. It has been generally stated that careful bleaching does not injure the cotton fibre, and that cotton yarns may increase 9 to 11 per cent. in strength thereby.

The wetting of yarn and pressure upon yarn during bleaching should do something towards adding strength.

Manchester Testing House.

Visits to the Manchester Chamber of Commerce and the Bradford Testing Houses about 1909 impressed the present writer with the much greater use of the Bradford Testing House for testing wool and wool tops, than the Manchester Testing House for testing cotton at that period. Since then great progress has been made at Manchester, there has been an increasing use of it for cotton in its various stages, and in carrying out tests on all manner of raw materials and finishing products both in sample and in bulk.

The first manager in 1895 was Mr. J. H. Lester, a degree man, who has recently been honoured with the first Gold Medal of the Textile Institute for scientific work in relation to the Textile Industry, and who was one of the original founders of the Textile Institute. Mr. Lester has for years past acted as testing expert for one of the greatest firms in the cotton trade and was succeeded at the Testing House by Mr. F. W. Barwick, under whose direction the general work has greatly progressed.

The war demanded very special and frequent attention to testing of textile materials, and the testing house did its share. Industries surrounding Manchester have discovered that accurate testing of their raw materials leads to more successful production. Independent testing of both raw materials and finished products is often very valuable; unfortunately there are often trade disputes regarding materials, and these are often referred to independent inspection, testing, and reports thereon. Corporations, large public bodies, and foreign Governments and contractors often require independent reports by responsible authorities.

It is often a condition that such reports shall be made before deliveries are accepted.

It is quite possible for independent reports by an accredited authority to suit both buyer and seller, especially perhaps in the case of large foreign orders, the buyer having the guarantee that deliveries are according to specification, while the British seller is relieved of much anxiety from fear of rejection after the goods reach the customer abroad. The present author has personally done a limited amount of such intermediate work.

The recent enlargement of the Manchester Exchange has enabled the Testing House people to move into larger rooms and to considerably extend and improve their instruments and testing facilities. Rooms at the Exchange have been planned to suit the particular requirements of the work, such as special lighting facilities and to controlled humidifying arrangements. A "carrier" system of humidifying is installed, which can automatically control the atmospheric moisture in the laboratories used for testing yarn

and cloth, and it is thus possible to carry out physical tests under uniform atmospheric conditions, the heating also being well attended to.

There are many instruments for testing cotton, yarn, and cloth, including a range of machines for testing the strength of the lightest voile or cambric cloths on the hand, up to heavy strong cloths requiring a breaking load of upwards of a ton on a strip 2 inches wide.

For moisture testing the "Assmann" type of hygrometer has been introduced, the air being conducted to the thermometer bulbs by means of a fan driven by an electric motor at a speed of 4,500 r.p.m.

Reflected and transmitted light may be used to aid in the inspection of whole pieces of cloth.

There are steam, gas and electrically heated ovens for testing moisture in cotton, yarn, cloth, wood-pulp or other materials.

Thread Testing.

Testings all prove that it is difficult to obtain uniformity in strength between one thread and another, this feature being shown up especially in single thread testing. May we not suggest that we are fortunate to obtain results as good as we do, when we consider the number of individual fibres or filaments which enter into the composition of an ordinary cotton yarn, and the work has to be done quickly and cheaply on a tremendous scale.

Tests have been made which demonstrated that tests for strength in an assembly of threads in lea form, gave a reduced breaking strength, compared with the aggregate of individual or single thread tests of the same yarns. Certain lea tests came out more than 20 per cent. weaker than the aggregate testings of many of the same threads tested singly.

When the same yarns, however, were assembled into a woven cloth, the breaking strength of the cloth came out stronger than might be expected from individual testings of yarn composing the cloth. The explanation may possibly be found in the manner of combining the threads into warp and weft, and the stronger threads helping the weaker much better than in lea testing of yarns.

Lea testing came out weaker in the aggregate than single thread testings, but the woven fabric came out stronger again proportionately.

In spinning and in selecting yarns for special purposes, it is well to remember that strength is wanted more in many woven fabrics, and evenness, fulness, and softness, more for hosiery purposes.

Cotton Yarn Tests.

Mr. R. A. Truesdale recently made certain careful tests from which he drew the following conclusions, the yarn taken being a good quality of Sakelarides of 1½ inch fibre length :—

"1. That after a period of one hour, cotton heated in a moist heat at 140° C. is reduced in strength.

"2. That yarn changes its colour when heated for one hour at a temperature between 120° C. and 140° C.

"3. That, in addition to the temperature factor, which reduces cotton strength, there is also a time factor. (Time taken for these tests was one hour.)

"4. Cotton heated in a small vessel containing the moisture of hydration is weakened more than that heated in the dry heat of an oven."

Electrical Driving for Small Plants.

The author has had considerable experience of electrical and gas engine driving as applied to comparatively small plants, and especially with intermittent use of machines and an electrical or gas supply from a permanent central source.

In the case, for example, of two or three moderately sized works driven by gas engines supplied with town's gas, the cost of gas was always low, and the gas was available at any time night or day. For the most part also the driving was very reliable.

At the best, however, it was a man's somewhat troublesome job (compared with electricity) to stop and start the gas engines, there were irritating times of engine variation, there was a certain amount of small, and apparently irritating periods of poor gas supply.

As a result the gas engines were scrapped, and electric motors installed with corporation electricity. These were started and stopped by any intelligent male or female operative, gave steady reliable drive which was always available, and there was little noise or smell.

The cost of running was greater than gas. The author experienced the same results in two different towns between 1917-20.

For a technical school or exhibition fitted with machinery electric motors are very advantageous when electricity is readily available from a central source. Some of the machines may have independent motors, and others run on the group system. All may be quiet one minute for demonstrating purposes, and in one minute any desired machine may be stopped or started.

Main Driving.

There are four methods of main driving more or less in use for cotton mills, viz. by wheel gearing, belts, electricity, and ropes. Various combinations of these methods are in use.

(*a*) Wheel gearing is the oldest method, and, until recent years, by far the most extensively adopted. It is now very seldom applied. It is very noisy, very dirty, and very subject to serious breakdowns and stoppages. It is yet retained in some mills which have had it for very many years.

In this system there is usually a large spur segment wheel on the crank shaft, driving a smaller wheel on the second motion shaft. This shaft drives by bevel wheels the upright shaft, and from the latter the line shafts of the various rooms are driven by bevel wheels. There is no loss by slippage with this system.

(*b*) In England main driving by belts has only been adopted in a few cotton mills, and most of these have discarded it again in favour of ropes.

The belts are very liable to slippage, and sometimes have given

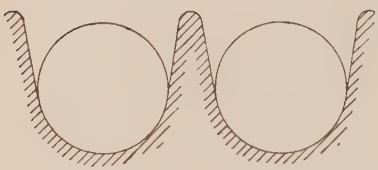


Fig. 122.

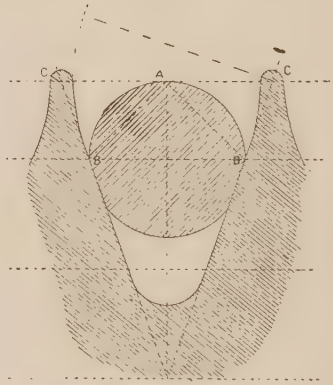


Fig. 123.

unsteady driving, and sometimes the breakage of a single wide belt has involved the stoppage of a large mill for a few days.

The cost of good belting appears also to be considerably more than that of the amount of good roping required to do the same work.

(*c*) In England the system of driving cotton mills by electricity has distinctly gained during the last few years. Especially is this true in the case of mill extensions. On the continent, it would appear that a fair number of mills have adopted this system, and it is by some considered as likely to receive extended adoption in the future.

Practically all the machinery at the Paris Exhibition in 1900 was driven through the medium of electricity, but not a greal deal in Lancashire at that time.

As a rule, the electricity is generated at a central station, and there are two methods of distributing it to the machinery, viz. by transmitting it to motors attached to the line shafts and then driving by the usual belts or ropes, or else by attaching the motors directly to the machines themselves. At the Paris Exhibition Messrs. Platt and Messrs. Brooks & Doxey adopted the former method, while the continental makers of cotton machinery appeared to prefer the more direct method. So far as the author could judge by carefully watching the machines, both methods appeared to be satisfactory,

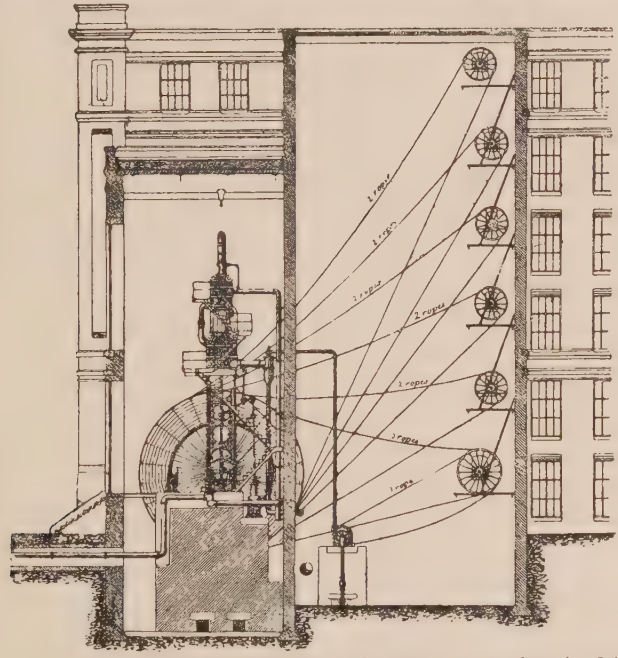


Fig. 124.—General view of the rope race and arrangement of main driving by ropes for a large cotton spinning mill.

but the direct method affords the great advantage of dispensing with the clumsy, troublesome, and unsightly driving belts all over the mill. Cost of the electrical method appears to be an objection to its use, although there are undoubted advantages in it. A third method of coupling up is much used for individual driving of cotton machines, the motor being placed on the floor, or in other adjacent position, and the drive is then from a small motor pulley up to a fast and loose pulley on the main shaft of the frame. Instead of belts, buffalo hide pinions are sometimes used.

(*d*) *Rope Driving.*—Rope driving for the last thirty years has been by far the most largely employed method of any for the main driving of cotton mills in England. The great size of the mills, the splendid steam engines, the convenient coal supplies, and the great success of multiple rope driving, have been great factors in maintaining main rope driving in favour, as well as the low cost under such circumstances.

It has been commonly stated that a mile a minute was the extreme limit of effective speed for ropes, but Messrs. Kenyon, of Dukinfield, quote a case of 7,040 feet per minute at a Lancashire cotton mill working satisfactorily, special and extra attention being given to the construction of the fly-wheel to prevent collapse. With rope driving there is hardly any loss by breakdowns, as a faulty rope can be dispensed with for a time.

It is considered that good ropes for main driving ought to last from twelve to fifteen years under average conditions.

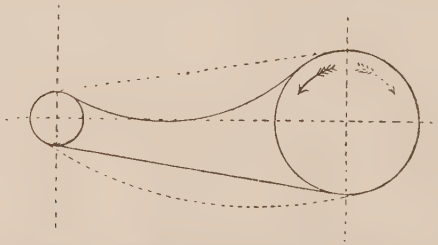


FIG. 125.—Rope driving, showing trailing span of rope at the top in order to obtain maximum bite of rope on pulley.

Generally the trailing span of the rope should be at the top in order to bite more of the pulleys.

The ropes should not exceed $1\frac{3}{4}$-inch diameter.

Curved sides to the pulleys encourage rolling of the ropes, and the rolling action diminishes their durability and driving power.

Rope driving is far quieter than wheels.

Inside Driving.

Referring now to the driving of (*a*) carding engines, (*b*) speed frames, (*c*) mules, (*d*) ring-frames.

The speeds of line shafts for all processes up to the mule and ring-frame may be, say, about 260 to 300 r.p.m. The high speeds of spindle required for the mule and ring-frame should have a higher speed of line shaft, say about 350 to 400. Higher speeds than these are used with electric driving.

It is good practice to drive a carding engine cylinder directly

from the line shaft by an open belt, giving about 160 to 180 r.p.m. to the cylinder.

As regards the pulley shafts of speed frames, it is good practice to drive them directly from the line shaft by a half-crossed belt. Sometimes gallows pulley driving is used for these machines, and is more powerful than the half-crossed belt, but is liable to dirty the cotton and the frame, and is more trouble to put on. The speed of the pulley shaft or driving shaft may be put down at about 240 to 260 for the slubber, 270 to 300 for the intermediate, and 300 to 400 per minute for the roving frame, but these speeds are only approximate.

As regards the mules, the general method is to have a counter shaft driven from the line shaft, and to drive the rim shaft by down belts from the counter shaft. The rim shaft speed may be put down at 600 to 900. In some cases of fine mules the counter shaft is not used, but the older system of direct driving from line shaft to rim shaft is in vogue. Mr. Moorhouse, the inventor of duplex driving for mules, invented a system of driving which is a sort of compromise between the old direct driving and counter shaft driving.

In the case of ring-frames the tin roller may make about 600 to 700 r.p.m. There are four systems more or less in vogue: (1) half-crossed belt, (2) direct driving by open belt, (3) gallows pulley driving. Because of the high spindle speed required, it is probably best to have gallows pulley driving, and these gallows pulleys are so disposed as to give a good full grip of the belt on the pulleys. (4) Driving by individual electric motor has become a favourite for ring-frames.

The tin rollers are now usually made in short lengths, coupled with strong shafts, and often made to run in Mohler self-adjusting and self-lubricating bearings, with cast-iron working on cast-iron.

An idea of the methods of driving a ring-frame will be gathered from the figures given in the chapter on ring-frames on this point.

1 and 2. Direct driving by half-twisted strap.

3. Gallows pulley driving.

4. Direct driving by open strap.

To determine hand of the frame, face the gearing end, looking lengthwise of frame, and note if the pulleys are to be placed on right or left-hand side.

Boilers.

When reliance is placed upon natural draught, a maximum height of 150 feet for the mill chimney may be taken, especially if the area of the flue has been set out properly.

In making boiler accommodation, allowance must always be made for heating in an English cotton spinning mill.

Draught gauges, draught recorders, water meters, combustion

recorders, water-glass gauges, steam pressure gauges, are adjuncts in more or less use for main driving by steam boiler and steam engine.

Fuel economisers are now applied to most boilers used for cotton mills.

Possibly made with four to ten pipes in a row, and eight is suitable in many cases. A boiler of 340 horse-power might take fourteen rows of eight tubes each.

Automatic stokers are much used for mill boilers. The coking stoker pushes or screws the coal on the furnace from the boiler front so that the coal becomes partially coked before reaching the main fire.

A sprinkler stoker supplies coal to the furnace on the fire top in very small quantities, intermittently, on different parts of the furnace. Good stokers reduce the smoke nuisance. Elevators and conveyers are sometimes used to convey coal from stack, barge or truck, direct to furnace.

Preventible smoke is black smoke or unburnt carbon, and may be greatly checked by obtaining more perfect combustion. There should be a plentiful supply of oxygen to the fuel, ample chimney and boiler provision, good stoking, either automatic or manual.

In Lancashire, water power driving of cotton mills is not much used, but formerly many mills were filled with large water wheels with the supposed object of helping the steam engines.

In other countries with a plentiful supply of water and good falls, there have been instances of machines being driven by separate small water turbines either directly, or through the medium of belts, ropes, or electric motors.

Large Gas Engines.

Gas engines of very large power are available up to 5,000 horse-power limits, but have not obtained much adoption in large cotton spinning mills in England, as compared with large steam engines, although the gas engine drive is considered to be the cheaper. Gas producers appear to be recommended for large installations and may work not only with coal, but also with sawdust, peat, wood, coke if desired.

A complete self-contained installation for gas engine driving may comprise the generator, or boiler equivalent, and also the engine proper. It is stated that such a plant requires neither boiler nor chimney. There are various types of gas producer. Experience with the engines and motors of motor cars and motor cycles should lead a person to readily understand the strokes and movements of a mill or works gas engine.

Very little success has been obtained in the way of installing Deisel or other oil engines in Lancashire cotton mills.

Ball and Roller Bearings.

The development of textile machinery, for present day requirements, has been so thorough and successful that further progress would appear to lie largely in the adaptation of mechanical improvements and the full exploitation thereof to textile purposes. One of the best examples of this class of progress is exemplified by ball and roller bearings. As this country has been so largely responsible for the progress of textile machinery, it is interesting to note that the same applies also to ball and roller bearings.

Consider a heavy weight being moved over a floor: common experience shows that considerable effort will be required if the weight is merely dragged along. In many cases the worker will interpose rollers between the weight and the floor, finding that his labours are thereby lessened. If the floor, the weight, and the rollers can now be considered to be perfectly hard and to have perfectly smooth surfaces, we have the root principle of ball and roller bearings. Instead of the wasteful sliding friction caused by dragging the weight over the floor, we have substituted pure rolling motion, which requires only the minimum effort because no energy is dissipated in generating heat or wearing the surfaces. A student of mechanics would explain this by stating that any point of the roller in contact with either of the surfaces is, at that moment, moving in the same direction and at the same speed as the point which it is touching. It is this fact which accounts for the remarkable results which can be obtained by using ball and roller bearings correctly.

The following table gives the results of an independent test carried out by the National Physical Laboratory. In each case a shaft of $2\frac{1}{2}$ inches diameter was supported in two bearings carrying a load of 2,300 lb.

	Standard Plain Hanger.		"Hoffmann" Ball-bearing Hanger (Patent).
	With Needle Lubricator.	With Oil Ring Lubricator.	
Starting effort . .	830 in. lb.	770 in. lb.	0·9 in. lb.
Revs. per Minute.	Co-efficient of Friction.		
80	·014	·015	·0013
130	·015	·014	·0014
250	·016	·013	·0015
500	·017	·012	·0016

Keeping the above authentic figures in mind, we now give a schedule of advantages which may be expected with ball and roller bearings. The machine maker and user with experience will be able to add many other advantages of peculiarly textile applications.

Starting Effort.—As seen from the foregoing, ball and roller bearings enormously reduce the starting effort.

Mechanical Advantage.—Less wear and tear on all belts, gears, etc. Belts need not be kept so tight. The starting gear of electrically driven machines benefits in reduced upkeep.

Textile Advantage.—The extremely even and light starting should effect many mechanisms concerned in the formation of uniform laps, slivers, yarns, cloths, and finished materials.

Running Effort.—It has been seen that ball and roller bearings will save about 90 per cent. of the power lost in plain bearings.

Mechanical Advantage.—This saving in power represents one of the big economies which the trade, including millwrights, cannot afford to neglect.

Textile Advantage.—Apart from the power saving, the extremely easy and uniform running qualities of these bearings can be made of use to eliminate strains on laps, slivers, yarns, and cloths, with consequent elimination of lap-licking, more uniform slivers, more even yarns (as for example by applying bearings to the counter faller shafts of mules), fewer broken ends, more uniform cloth.

Heat.—As ball and roller bearings do not absorb driving power, they cannot develop heat.

Mechanical Advantage.—Bearings may be run at higher speeds without overheating or seizing, meaning higher production and smaller pulleys.

Textile Advantage.—There are many spots in textile machines where too much heat is liable to develop. A few of these are: footstep of Crighton opener; rim shaft, loose pulleys and carrier pulleys in mule headstock; shedding motion cam rollers in looms; heavily loaded line-shaft bearings; footsteps of vertical driving shafts; fancy roller in cotton waste cards. The insurance companies take a very favourable view of the application of ball and roller bearings in this respect.

Wear.—The pure rolling motion of ball and roller bearings cannot give rise to wear unless dirt is present.

Mechanical Advantage.—No adjustment, or replacement is necessary. Shafts are not worn and weakened. Gears can be kept perfectly meshed.

Textile Advantage.—The advantages will fall largely under the headings of eliminating adjustment and attention, particularly where fine settings are involved. The footstep of Crighton opener is a good example, also the carding engine, the crank arm of a loom so fitted enables perfectly parallel beating-up to be obtained continu-

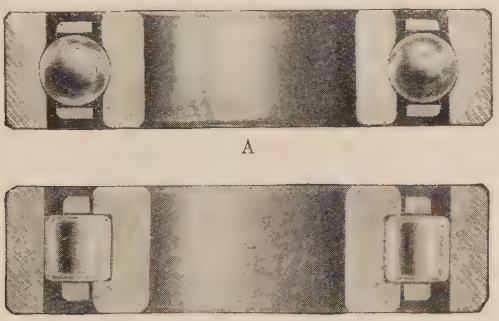
ously; the doll heads on drying cylinders can be made steam tight as well as frictionless.

Lubrication.—Ball and roller bearings do not require lubricant as ordinarily understood. Grease may be used to protect the highly polished steel surfaces, and will require renewing only at intervals ranging from three to twelve months.

Mechanical Advantage.—Great economy of lubricant and labour. Lubrication of difficult or inaccessible bearings simplified.

Textile Advantage.—The bearings which give most trouble in this respect in textile machines will be well known and may include troublesome line-shaft bearings, loose pulleys, etc., pedal rollers on scutchers, main cylinders of hardwaste breakers, mangle and calender bearings.

Cleanliness.—As only a small supply of solid lubricant is required, and as this can be completely retained in the bearing housing, perfect cleanliness results.



A

B

FIG. 126.

Mechanical Advantage.—The dirty oiliness of machinery, floors, etc., is abolished. No drip tins are necessary.

Textile Advantage.—The soiling of valuable material in all stages from the raw to the finished fabric is eliminated.

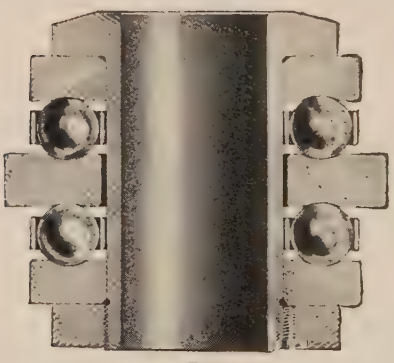
At A is shown a single row ball journal bearing.
At B ,, ,, ,, roller journal bearing.
At C ,, ,, ,, single ball thrust washer.
At D ,, ,, ,, double thrust washer.
At E ,, ,, ,, self aligning bearing type M.T.W. carding engine (including fancy rollers), crank arm of loom, mangles and calenders, etc. (See Figs. 126-127.)

Speed.—With no troubles from heat or lubrication, and having no large power consumption, ball and roller bearings may be run at very high speeds without complications. The effect of this on production will be clear.

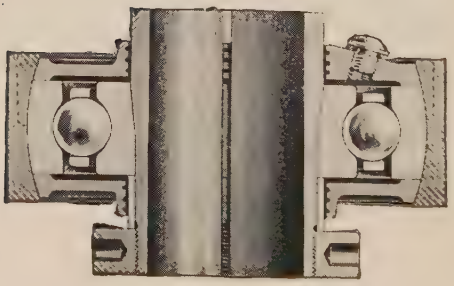
Compactness.—For a given load, a ball or roller bearing is much shorter than a plain bearing. This simplifies the design of machines in many instances and means more machines per given floor space.

From the foregoing will be seen some of the progress which has

C



D



E

FIG. 127.

already been made, and the matter has been so sub-divided that the reader may know along what lines to pursue further inquiries. It is now necessary to describe the types of bearings available and their various requirements.

Bearings which support a load at right angles to the shaft (e.g.

as found on all horizontal shafts) are called journal bearings. Journal bearings are made both with balls and rollers, which run between special tracks called races. All these parts are made of the finest steel hardened and most accurately ground to size. A gun-metal cage is used to keep the balls and rollers in position and to prevent them rubbing against each other. These bearings are illustrated in Figs. A and B.

Swivelling or self-aligning journal bearings are obtained by providing a spherical surface outside the bearing, thus forming a ball and socket joint which will move in any direction. Fig. E shows this principle applied to a ball journal bearing. The illustration shows the type of swivelling bearing which is complete with its own end-covers and these also are arranged to swivel. Consideration will show that this is necessary to obtain a dust-proof bearing, of which more will be said later. This illustration also indicates the split taper sleeve which facilitates fitting to the shaft. All types of ball or roller journal bearings may be fitted with these split taper sleeves if desirable.

Bearings which support a load parallel to the shaft (e.g. footstep of Crighton opener) are termed thrust bearings. They are only obtainable in the ball type, as rollers are not feasible. The general construction is similar to journal bearings, but the races consist of discs side by side instead of concentric rings. Fig. C shows a ball thrust bearing for taking thrust in one direction, and Fig. D shows the same principle applied to a bearing for taking thrust in both opposite directions. In this latter case, the bearing is supplied with a sleeve and nut which is locked to give an adjustment without either backlash or danger of overload.

Swivelling thrust bearings are provided with spherical or conical seats, which are often incorporated in the actual mounting.

Ball and roller bearings are simple to use, being made in a wide range of international standard sizes, suitable for every conceivable duty. Loads up to 200 tons and speeds up to 40,000 r.p.m. are being successfully dealt with, and this field covers everything met with in textile work. No expensive scraping or bedding down is necessary. However, it must be remembered that the characteristics of ball and roller bearings differ materially from those of plain bearings, and attention to the following points is necessary in order to obtain the best results. In case of doubt, the advice of a reputable bearing manufacturer should be sought.

The Bearing. Design.—The design of the bearing must follow the lines defined as long ago as 1900, and the illustrations given herewith are typical.

Manufacture.—Only the best material and highest class of workmanship is permissible. The best makers guarantee the accuracy of the balls to within $\frac{1}{10000}$ inch.

The Mounting. Design.—The bearing must be selected correct in size and type for the work. Swivelling bearings must always be used except where alignment can be guaranteed. Journal bearings must not be subjected to continuous end thrust of more than nominal magnitude. Roller journal bearings should be used in preference to ball journals to deal with shocks, whether due to the nature of the load (e.g. waste breaker cylinder) or to a heavy mass of large diameter revolving at a high speed (e.g. armature of large electric motor). In any case roller journals are preferred for all very heavily loaded journals, having a 50 per cent. increase of load-bearing capacity over the same size ball journal (e.g. mangles and calenders).

Manufacture.—All parts in contact with ball and roller bearings must be machined, and must be truly round or flat and "square" as necessary. The bearing manufacturers specify certain parts to be fitted with "push fits" and others with "light tapping fits." These instructions must be followed.

Protection.—Ball and roller bearings must be kept free from all foreign matter, whether dirt or moisture. They should not be unpacked from their boxes until actually ready to fit. The life of a bearing, other things being equal, depends on its cleanliness, hence the importance of the dust-proof swivelling bearing with swivelling end-covers, Fig. E.

Lubrication.—These bearings do not require lubrication as ordinarily understood for plain bearings. However, something is necessary to protect the highly finished balls and tracks. A pure mineral grease, about the consistency of vaseline, free from acid, alkali, moisture, chalk or graphite, is the best, and it should be stored in a clean tin with a lid. For ordinary purposes a small charge, preferably with a grease pump, every twelve months is sufficient. If the temperature is high or the atmosphere dusty, this period may be reduced to three to six months. For very high speeds oil may be desirable.

Maintenance.—It is not too much to say that a properly selected and fitted ball or roller bearing should not require any maintenance whatever. Pure rolling motion cannot give rise to wear, and any ball or roller bearing which does not last as long as the machine should be made the subject of inquiry by the designer and the bearing manufacturer.

Similarly, these bearings should not show any appreciable temperature rise, and if this occurs it should be treated as a symptom which requires explanation. In many cases, excessive or unsuitable lubricant will be the cause.

The author is indebted to the Hoffman Manufacturing Co. for assistance with the foregoing article, per Mr. W. E. Baker. Both Mr. Baker, and also Mr. Harold Hill of Messrs. Dobson & Barlow,

have lectured at Bolton Technical School on Ball Bearings applied to Textile Machinery.

Electric Driving for Cotton Mills.

Increased cost of coal, continual improvements in electrical matters generally, proved convenience, economy, and efficiency with which the latent heat energy of coal may be turned into electric power in large installations; convenience and ever-increasing reliability in conducting the electric current from generating station to the mills; such items as these are leading towards the increased use of electricity in our cotton mills.

Steam engine builders are suffering in consequence—at any rate in regard to any direct new work in cotton mills. Any full-sized spinning mill well set out during the last twenty years, with well-constructed steam engines, a good rope race, well arranged and regulated steampipes and connections, can still be driven more cheaply by steam than electricity in England.

The driving arrangements of cotton mill shafting and machinery are gradually becoming more adapted to either individual or group driving.

Chain Driving.

We do not find much chain driving in cotton mills, but engineers have directed attention to the features of chain driving, and there can be no doubt that chain construction has vastly improved of recent years. The "swing" motion of a bobbin and fly-frame has been converted from wheel to chain drive for some years by some firms and possibly this application will develop. Ordinary bicycles afford very familiar examples of chain driving. Chains are now often used instead of quadrant bands on self-acting mules.

For main driving chains may be made from mild steel, and consist of plates, pins, bushes, and rollers; which parts, when put together, constitute a flexible band of fixed length, capable of running upon wheels having suitable teeth cut in their periphery.

The flexibility is obtained by knuckle joints, and implies no bending or straining of material.

Chain driving is a positive transmission and there is no lost motion. In general the distance between centres of shafts connected by wheels will be much less than is usual with belts and ropes, ranging mostly from 2 to 9 feet, but much greater distances are used if desired. A good speed ratio is anything up to 6 : 1 but higher has been used. The wheels for chain driving are usually smaller than with other forms of drive.

Driving chains require every care in erection, more perhaps

than belts or ropes. Chains require lubrication and cannot be crossed like belts or ropes.

Chain drives furnish a convenient means of transmission from electric motors to line shafts, possessing high efficiency, quietness, absence from vibration, and adaptability. They will operate to over 200 h.p.

An American Mill.

An English visitor to the U.S.A. in 1920 wrote as follows:—

"The American people specialise. At a little village, Salem, there is a mill equipped with American machinery and plant throughout.

"It contains 160,000 ring spindles in two rooms; also 3,900 looms, and they are only making one quality of cloth, eventually made up into sheetings and pillow-cases.

"There are 80,000 ring spindles in each of the two rooms, spinning only four different counts of yarn, and using 1,000 bales of cotton in a week. The mill was driven electrically, as most American mills are. The card-room was driven from underneath, and there was no dirt flying from straps upon the bobbins. There were no counter shafts overhead. Each shaft had its own motor, and group driving was the arrangement in the card-room, where there were 420 carding engines.

"The ring-frame drive was a compromise between the group drive and individual driving. The ring-frames were driven by a vertical drive, one motor attached to the ceiling driving four ring-frames, the motor being 30 h.p.

"In America men work on slubbing frames, one man on a frame; also on draw-frames. If we had men for this work in Lancashire, they would be more reliable; and it is only a matter of wages.

"The American idea of good middling cotton is our fully good middling."

A Mill Converted from Wheel Drive to Electric Drive.

Recently, the author's son, Mr. Wilfred Thornley, acting as mill manager, carried out a change as indicated from old steam engine and wheel drive, and he prepared the diagrams given herewith.. (See also pages 519-520.)

In ring-room and card-rooms long lines of shafts and many wheels were dispensed with, and motors of about 150 h.p. directly secured to the line shafts.

For the mule-rooms the motor was kept on the basement, and

from this several ropes extended upwards along a specially con-

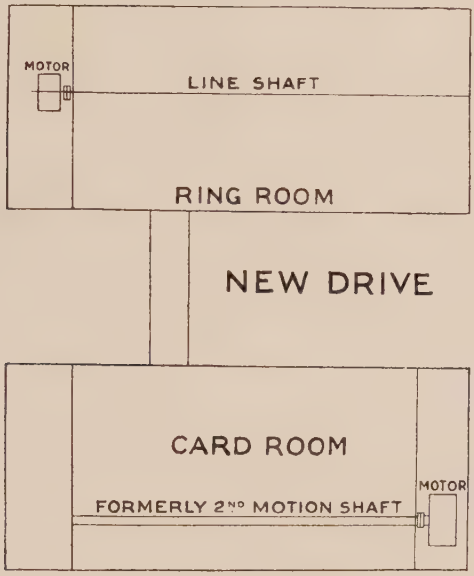


FIG. 128.

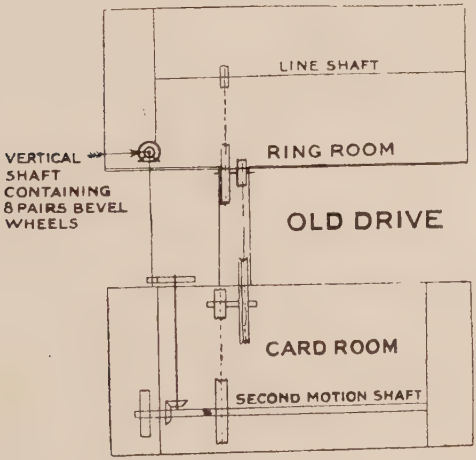


FIG. 129.

structed rope race, a chief reason for this being the fact of only

having a few mules on each floor and a good group drive from a large motor being desired.

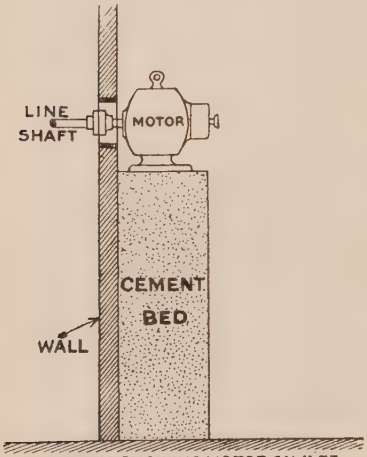


Fig. 130.

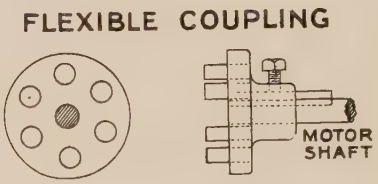


Fig. 131.

Flexible couplings from motor to line shaft for the direct coupling in ring and card-rooms.

A great saving was effected in coal and labour. Electricity obtained from a large central power company.

CHAPTER XII.

MILL PLANNING AND ARRANGEMENT OF MACHINERY.

Introduction.—Cotton spinning mills have not always been built on the best sites or in the best natural positions in regard to water, composition of soil, shelter from adverse winds, railway, water or road transit.

During a Lancashire mill building boom, it was said that promoters only had to catch a glimpse of a green field near certain localities to say they would put a mill there.

Nevertheless, in choosing a site and deciding to build a spinning mill such conditions as stated below should have every consideration and be obtained as far as convenient.

Atmosphere.—(1) A warm humid atmosphere, although artificial heating and humidifying will do much to counteract somewhat unfavourable conditions. Cotton spinning mills have often done well in rather high positions although a valley open to moist winds and protected from dry winds is best.

The writer is acquainted with one or two mills near to good water supply and in low positions, but often have very bad spinning owing to north or east winds channelling and driving down the valley, which, in a manner of speaking, is open at both ends.

Site.—(2) A good solid subsoil is required for the five to seven storey mills usually built for mule spinning in England, or the four storeys of ring-spinning mills.

A clay subsoil forms a solid foundation, retains moisture, and, if required, the dug-out clay may help in making the bricks for the mill.

Transit.—(3) Regard must be had to facilities for bringing coal, raw cotton, machinery, or other goods to the mill, and for taking away the spun yarn, cotton waste, ashes, or other materials.

Proximity to railway, canal, or main roads is always an advantage. For a mill to be just outside a railway's defined carting area has often been a source of trouble and cost, but motor transit is diminishing such troubles.

Vicinity.—(4) It is all the better when mills are reasonably near to the raw cotton and spun yarn markets, the supplies of coal, and the makers of machinery the mills use.

In regard to (3) and (4) it may be stated that the recent great increase in the use of heavy and light motor vehicles has very much improved the conditions at many mills, and was favoured during the period of Government control of railways after the great war.

Many spinning firms have found they could have their cotton fetched by motor from Manchester or even Liverpool, and their yarn delivered to home customers, with quick motor return of empties, by using their own or hired motors.

Labour.—(5) Regard should always be had to the character and amount of labour likely to be available. Many firms have been practically ruined by staffing with careless and incompetent workpeople.

Height of Mills.—(6) In England storey mills are proved best for cotton spinning, the limited number of shed buildings in use not giving the best results in heating and economy of ground space, although perhaps good for supervision of labour, internal transit of material and lighting—considerations which have caused many shed mills to be erected in other countries.

Shed buildings, or two-storey buildings, are perhaps best even in England for small plants. The writer has been in old spinning mills containing no more than ten pairs of mules, mill six storeys high, all blow-room and card-room machinery in ground or basement floor with shed extensions, and each of the five higher rooms containing just two pairs of mules. Efficient supervision, economical cop and bobbin carrying prompt attention to breakdowns, were scarcely possible under these conditions.

Water Supply.—(7) A regular and sufficient water supply is another desideratum in connection with steam engines and boilers, and these should be placed adjacent to the water supply or competent water conduits and pipes laid down.

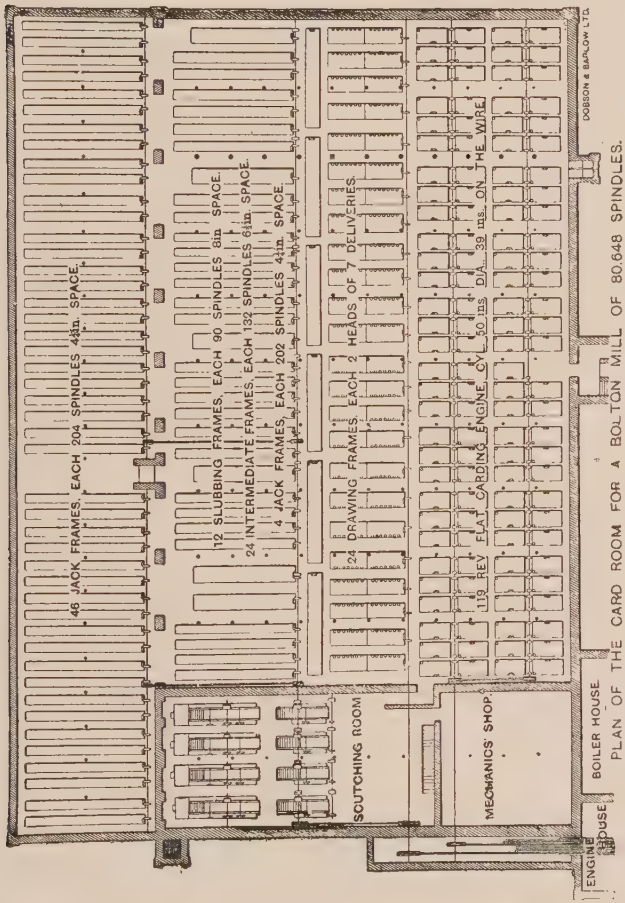
The rapid extension of electricity, tendency to centralise generating stations in large units, and convenience of distributing the current over large areas, have in some cases eased the question of large water reservoirs for mills, especially for smaller concerns in districts well served by Corporation or Company current.

Range of Work.—(8) There are always preliminary questions of whether a mill shall be all ring-frames, all mule spinning, proportions of both ring and mule spindles, all weft, all twist or warp, proportions of warp and weft, fine, medium, or coarse spinning, the range of counts, kind of cotton expected to use, total number of spinning spindles.

Width of Mill.—(9) A mule spinning storey mill is generally required to be higher and wider than a ring mill. Widths may be possibly 130 feet for mules and 95 feet for rings, both inside dimensions.

Since about 1890 mules have been largely standardised at about 126 to 128 feet long, since much longer carriages and lines of rollers have proved unwieldy and shorter mules are more expensive to operate in England.

At about 95 feet width 20's to 30's counts, two full length ring-


46 JACK FRAMES, EACH 204 SPINDLES 4½in. SPACE
12 SLUBBING FRAMES, EACH 90 SPINDLES 8in. SPACE
24 INTERMEDIATE FRAMES, EACH 132 SPINDLES 6¼in. SPACE
14 JACK FRAMES, EACH 202 SPINDLES 4½in. SPACE
24 DRAWING FRAMES, EACH 2 HEADS OF 7 DELIVERIES
116 REV. FLAT CARDING ENGINES, 50 ins. DIA. 39 ins. ON THE WIRE
SCUTCHING ROOM
MECHANICS' SHOP
BOILER HOUSE
ENGINE HOUSE
DOBSON & BARLOW LTD.

PLAN OF THE CARD ROOM FOR A BOLTON MILL OF 80,648 SPINDLES.

FIG. 132.

frames can be placed end to end across the room, leaving a wide central passage of 5 to 6 feet, and end passages of $1\frac{1}{2}$ to 2 feet.

There may be four frames each 3 feet wide in a bay 22 feet wide, with satisfactory back and front alley ways.

Card-Room Arrangements.—Each mule may run across the

width of an upper room in a six-storey mill, and two ring-frames across each narrower upper room of a ring mill. Four storeys for a ring mill, six storeys for a mule mill.

Referring now to the card-room, perhaps the most distinctive primary point to settle is: whether the cards shall be massed down

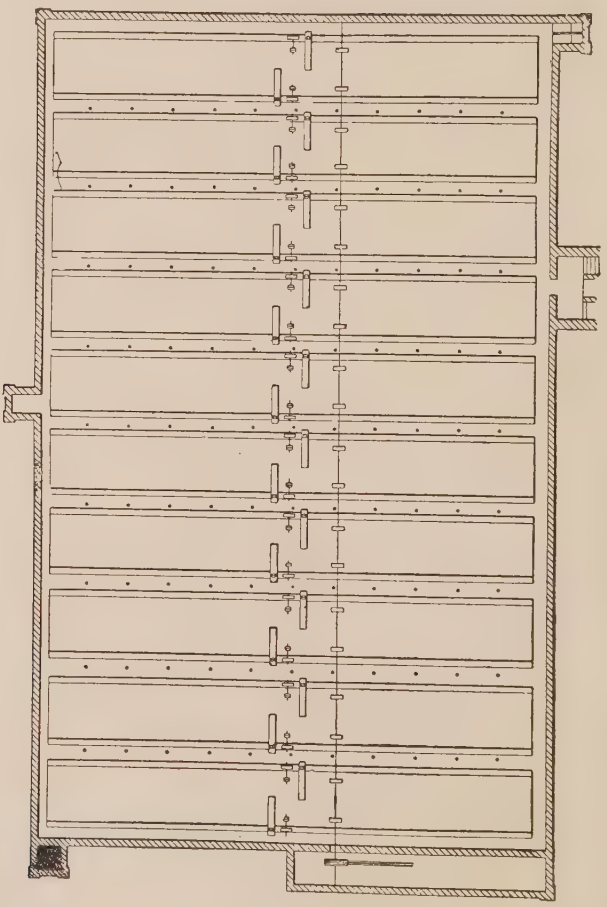


Fig. 133.

one of the long sides of the room, or shall be assembled at one end across the width of room.

(*a*) Whenever a wide range of counts, or distinctly different mixings of cotton are used, requiring the cards to be divided out

into "preparations" the cards and frames lend themselves best to such division when placed down the long side of room.

At the opposite long side of the room from the cards there may be the main passage with bobbin boxes arranged in window bottoms to best advantage.

(*b*) Assembling the cards at one end is perhaps best for lap carrying, having a wide central passage which favours supervision and assembling bobbins to the hoist in a central bay. Suitable for one preparation or possibly two.

Shafting.—(11) Collective driving has been usually considered best for the machines of a cotton spinning mill. Positions that have proved satisfactory for individual motor driving are for openers, ring-spinning, and ring-doubling frames. The shafting for a properly set out mule spinning room usually extends right across the top of all the mule creels, 9 to 12 yards for the headstocks.

With cards down the long side of the mill, two long lines of cards may be driven from one central overhead shafting making possibly 200 r.p.m., which allows the card cylinder pulleys to be only of slightly larger diameter than their line shaft drivers. Often the line shafts makes a higher number of revolutions per minute, and the top driving pulleys must be correspondingly reduced in size—a position which has arisen especially in the case of motors coupled directly to the line shafts.

A second line shaft in the above card-room could extend parallel to the card line shaft, and over the inside ends of the long row of fly-frames so as to drive all the fly-frames by half-crossed belt, owing to spindle speeds required, this shaft would best make about 300 r.p.m.

With two ring-frames reaching across the width of room, thus giving two long rows of frames which could be driven from one line of shafting making 280 to 350 r.p.m. according to counts and spindle speed required.

With cards massed at one end of room there may be one line of shafting for frames and counter shaft for cards, with speeds modified in consideration of frames and cards driving from same long line shaft.

Summary.

Points above given may be summarised as below :—

1. A warm, moist atmosphere.
2. A good solid subsoil.
3. Excellent transit facilities by road, railway, or canal.
4. Vicinity of cotton and yarn markets.
5. Competent, available labour.
6. Height of cotton-spinning mills.

7. Water supply.
8. Range of counts and cotton.
9. Width of mill.
10. Card-room arrangements.
11. Shafting.

The large textile machine shops keep efficient staffs and drawing offices, capable of planning, arranging, and proportioning the mill machinery, but should be supplied with information such as specified below, as a basis.

1. The number of spindles intended to start, and how many will be mule or ring, whether twist or weft, and weekly or hourly productions aimed at, with hours per week.

2. The range of counts proposed to spin and general kind of cotton proposed to use.

3. All the better if a rough plan of the site is available for the machine makers, showing points of compass, mill chimney, water supply, boilers, engines, and roadways.

4. The kind of mill to be built, whether storey or shed, and how many storeys in the former case.

Coal Strike. Oil Fuel.

The middle of 1921 was distinguished by a coal strike of more than ordinary magnitude due to proposed reductions in wages and re-adjustment of conditions created by the war and immediately preceding boom years.

The cotton trade had already lost a great deal of its prosperity, and many cotton mills stopped altogether due to inability to obtain coal and not having profitable business in hand.

Many other spinning mills, however, ventured on the important departure of having their boilers connected to the consumption of oil fuel instead of coal, aided in this idea by the fact hat suitable oil at the moment was in somewhat abundant supply.

It can be said at once that the oil-burning methods enabled many mills to keep going, but in Lancashire at any rate, oil has not reached that low price and abundance to supersede coal under normal conditions, and coal soon came back to its own in our spinning mills after the coal dispute was settled.

Various firms undertook the application of oil-burning installations, several methods soon came into use, and there was considerable variation in detail and in form application.

Perfect combustion, freedom from danger, economy in fuel consumption, ability to raise and maintain sufficient steam, were of course aimed at in every case, but were not

It is desired to develop the hottest possible fire, and to transmit as great a proportion of heat as possible to the water in the boiler,

High economy requires a low temperature of the gases leaving the boiler, and that heat shall be mostly absorbed by water in the boilers and economisers. It is not desirable to send gases up chimneys at the wasteful heats of 750° F. or higher.

The present author has been at oil-extracting works when the fires have been almost out in the morning and the attendants have recklessly thrown crude oil on the fires quite safely. At other times there has been a sudden damping backwards and great flames issuing from the furnace fronts.

This is typical of what occasionally happened in some of the earlier applications of oil fuel to the boilers of spinning mills. A layer of coal as a foundation and oil fed and distributed in the most careful, regular manner were fundamental to good results, the work aided by steam.

Under good conditions, with a well-designed and well-applied installation, under careful supervision, an oil-fired plant may need less attention than coal firing, and it can be got up from cold perhaps sooner than coal firing. If shut down at night under a good steam pressure, with dampers dropped, and inlets closed, a very fair steam pressure may be expected next morning and good steam may be got up in less than one hour.

Both town gas firing and oil firing are more expensive than coal firing, especially in our textile districts.

Take one example of oil firing.

The objects were to obtain early and complete combustion. The oil and steam were fed to the inner chambers of the burner tangentially, so that a whirling movement was developed. A further supply of steam was admitted through the double nozzle also tangentially. The valve was of the needle type.

In this particular case the burner was of elliptical shape, and the oil atomised by the steam jet took an elliptical form and entered a combustion box similarly constructed, leaving in an elliptical flame giving uniform heat throughout the furnace. The combustion box was brick lined, and a radiant heat was developed before the oil entered the furnace. The burner was designed so that a large or small supply of oil could be admitted as desired.

One great effect of the great coal stoppage of early 1921, and the consequent great stoppage of smoke, was the remarkable clearing and lightening of the atmosphere in many Lancashire town districts. Never before—not even on Sundays—had inhabitants been able to see so far, or been favoured with such visibility. Especially was this true on clear sunny days with a moderate amount of wind. With common, ordinary bright sunny days panoramic views were obtained hitherto unknown to most people. At this time it was really due to industrial dead-lock, disaster, and stagnation, but the advent of great central producing centres for

electric power and light may yet help in killing the smoke nuisance more fully than anything else.

Cotton Stair Treads.

There are stair treads made from *cotton* which last longer than cast iron.

These stair treads are safe even for careless users.

The treads fit on the nose of the step and so take all the heavy wear, and even if worn out to paper thickness act with satisfaction.

Revolving Flat Card.

Constructed to give the maximum rigidity necessary for accurate setting and perfect running. Facings, joints, pedestals, and brackets steady-pinned in position where necessary, obviating re-adjustment after being set to work. The tendency of ordinary keys to slip off their flats when subjected to the strain of starting is overcome by keying on all pulleys and most wheels by patent semi-circular keys recessed in the shafts.

Ring Spinning Frame for Twist.

Frame ends and spring pieces made with loose feet to adjust to uneven flooring. Rollers carried on strong angle beams supported by spring pieces; framing stiffened by specially-constructed girder rails which carry spindles, ring rails, and lifting motion. The whole frame is rigidly braced together to ensure freedom from vibration when spinning at high speeds.

Electrical Driving.

Recently the writer saw an arrangement in which a 60 h.p. motor of 400 r.p.m. was directly coupled to a line shaft which was made to drive fourteen ring frames.

Instead of direct coupling of motor shaft to line shaft, it is considered better in some cases to fit a large wheel on the line shaft, erect the motor on a pedestal near to, apply a small driving wheel to the motor shaft, and in this way use a high speed motor and drive the line shaft at a reduced speed. To prevent noise and breakdown laminated gear wheels may be used.

Dr. Ure wrote as follows in 1836:—

"Mr. Fairbairn has very recently erected a spinning and weaving factory, upon the most improved plan, for Messrs. Bailey, of Stayley Bridge, of which the following is the estimated cost:—

	£
Buildings for containing the machinery	30,000
Engine-house, boiler-house, and gas-house	3,000
Two steam-engines, of 110 h.p. each, with mill gearing	8,800
Steam-pipes for heating the mill, and gas-pipes with gas apparatus	2,400
40,000 mule spindles	11,500
Preparation machines, including cotton cleaning and opening	12,000
1,280 power-looms, with appurtenances	18,000
Contingencies	2,300
Total cost of the factory	£88,000

Or probably, £90,000.

"An additional weaving shed is proposed, which will increase the looms to 1,480, and the outlay to £100,000. The power of these united steam-engines is conveyed from the rim of the fly-wheel, which is a new plan of gearing mills—one already tried by Mr. Fairbairn in another mill, and found to exceed his most sanguine expectations of steady impulsion. Thus the fly-wheel becomes, in fact, the great spur wheel, so as to serve the double purpose of regulating the motion of the engines, and transmitting the power to the mill shafts."

Mill Planning Calculations.

In arranging and proportioning the machinery for a new mill or for an extension to an existing plant, it is necessary to adopt or assume certain data from the previous successful experience of a person or firm sufficiently expert. All the data for the machinery cannot be established without calculation, because one working principle depends upon or affects another, and if certain particulars are more or less rigidly laid down, others must be calculated therefrom. Drafts, hanks or counts, number of spindles and productions, are, for example, interdependent.

This will be best illustrated by one or two worked out examples.

Example 1.

It is proposed to build a large new cotton-spinning mill to contain 110,000 mule spindles and to spin fine counts of combed yarns, say about 120's basis.

It has been decided to adopt approximate data as laid down in the table on p. 550 given. The working week herein assumed is 56½ hours less stoppages; and for productions a working week of any other number of hours would be proportionate.

The table comprises weekly productions, counts of material, twist per inch or twist constant, and possible losses in waste per cent.

Cotton Spinning Plant.

To produce 51,244 lb. of yarn, 20's counts, per 56½ hours.

Total Weight of Yarn, etc., Required Per 56½ Hours.		Weights of Slivers, etc.	Calculated Production Per 56½ Hours.		Speeds. D. = Doffers F.R. = F't Rol'rs S. = Spindles	Calculated Total Machinery Required.
At	Lb.	Hank.	Lb.		Revs. Per Min.	
Scutcher	55,204	14 oz. scutcher lap	14,000	Per scutcher	Beater 1,150	4 finishing scutchers
Carding engine	53,858	·125 card sliver	900	,, card	D. 14·5	60 card'g engines
Drawing frame	53,325	·125 drawing ,,	900	,, finishing / delivery	F.R. 275	60 draw'g frame / finish'g del's
Slubbing ,,	52,797	·6 slubbing ,,	106·6	,, spindle	S. 650	495 slub'g spindles
Intermediate ,,	52,274	1·2 interm'e ,,	46	,, ,,	S. 750	1,136 interm'e ,,
Roving ,,	51,757	3. roving ,,	17·3	,, ,,	S. 1,150	2,991 roving ,,
Ring-spinning,,	51,244	20's ring spinning	2·55	,, ,,	S. 8,500	20,096 spinning ,,

Specification of Machinery on Plan.

1 Bale breaker with mixing lattices.
2 Porcupine feeds with hopper feed attached and dust trunks. 2 combined openers and scutchers.
8 Scutchers (4 intermediate and 4 finisher).
63 Carding engines, 37 inches on wire, for 37½ laps.
9 Drawing frames (each) with 3 h'ds of 7 per h'd (= 63 F.D.).
5 Slubbing frames of 106 spindles (each), 17¼ inch gauge, 10-inch lift, 5⅞-inch diameter of full bobbin.
8 Intermediate frames of 140 spindles (each), 19½ inch gauge, 10-inch lift, 5-inch diameter full bobbin.
17 Roving frames of 180 spindles (each), 20½-inch gauge, 7-inch lift, 3¾-inch diameter full bobbin.
32 Ring-spinning frames of 328 spindles (each), 2¾-inch gauge, 1¾ inch ring, 6 inch lift, for twist.
24 Ring-spinning frames of 400 spindles (each), 2¼-inch gauge 1¼ inch ring, 5 inch lift, for weft.

From the data herein adopted other data that must be calculated will be :—

1. The total weekly productions from each kind of machinery.
2. The total quantities of each kind of machinery.
3. The speeds of spindle at fly-frames and machinery.

Number of spindles per machine decided by previous experience, dimensions of rooms, gauges of spindle, required sizes of bobbins and cops.

The exact sizes of change wheels at all the machines will be later determined by calculations based on counts, drafts, speeds, and number of teeth in other related wheels.

Some machines contain many more change wheels than others. On all machines diameters of pulleys fundamentally affect speeds. On combers, draw-frames, cards, openers, scutchers speeds and draft calculations and wheels are the usual items. On fly-frames we have change wheels for draft, twist, lifter, and bobbin building. On mules we have change wheels for draft, cop-building, drag or carriage gain, speed, twist. Rim pulley and tin roller pulleys for twist, quadrant pinions. On fine mules the double carrier for short shaper movement.

Assumed Data.

Machine.	Counts.	Weekly Productions.	Twist Multipliers.	Waste Loss.
Opener . . .	—	—	—	5 per cent.
Scutcher . .	Lap, 10 oz. per yard.	—	—	2 ,,
Carding engine . .	·250	270 lbs.	—	4 ,,
Sliver lap-Machine .	—	2500 ,,	—	$1\frac{1}{4}$,,
Ribbon lap machine .	—	2500 ,,	—	$1\frac{1}{4}$,,
Comber. . .	·225	320 ,,	—	20 ,,
Draw-frame .	·240	330 ,,	—	1 ,,
Slubber. . .	1 hank	54 hanks per spindle	At all fly frames twist per inch to $= \sqrt{\text{counts}} \times \cdot 75$	1 ,,
Intermediate	$2\frac{1}{2}$,,	50 hanks per spindle		$\frac{1}{2}$,,
Roving frame	$6\frac{1}{4}$,,	38 hanks per spindle		$\frac{1}{2}$,,
Fine jack frame . .	20 ,,	30 hanks per spindle		$\frac{1}{2}$,,
Mule . . .	120's yarns	18 hanks per spindle	At the mule twist $= \sqrt{\text{counts}} \times 2 \cdot 75$	2 ,,

Note.—For calculation purposes, take actual weekly running hours of fly-frames at 50 hours per week, and of mule at $52\frac{1}{2}$ hours. The slubber loses much more time in doffing than a roving or jack frame.

In calculating rate of spindle speed at the mule, assume 12 seconds per minute to be lost in backing-off and taking-in.

Productions.

1. $\frac{\text{spindles. } 110{,}000}{120\text{'s}} = 16{,}500$ lb. of yarn from the mules per week.

2. $\frac{\text{counts. } 16500 \times 100}{98} = 16836{\cdot}7$ lb. total from fine jack frames.

Especially must be noted the method $\frac{100}{98}$ of allowing for the loss in waste. It is easy to adopt a wrong method which may not materially affect the result in small percentages, but would do so considerably in the very large waste per cent. at the combers, or even at the carding engines.

3. $16836{\cdot}7 \times \frac{100}{99{\cdot}5} = 16921{\cdot}3$ lb. from roving frames.

4. $16921 \times \frac{100}{99{\cdot}5} = 17006$ lb. from intermediate frames.

5 $17006 \times \frac{100}{99{\cdot}5} = 17091{\cdot}4$ lb. from slubbers.

6. $17091{\cdot}4 \times \frac{100}{99} = 17264{\cdot}04$ lb. from draw-frames.

7. $17264{\cdot}04 \times \frac{100}{99} = 17438{\cdot}3$ lb. from combers.

8. $17438{\cdot}3 \times \frac{100}{80} = 21797{\cdot}8$ lb. from ribbon machines.

9. $21797{\cdot}8 \times \frac{100}{98{\cdot}75} = 22353{\cdot}4$ lb. from the carding engines.

10. $22353{\cdot}4 \times \frac{100}{96} = 23284{\cdot}7$ lb. from scutcher.

11. $23284{\cdot}7 \times \frac{100}{98} = 23760$ lb. from opener.

12. $23760 \times \frac{100}{96} = 24750$ lb. from mixings.

In this mill spinning fine combed yarns it will be noted that 24,750 lb. of raw cotton are required to produce less than 17,000 lb. of yarn.

Quantities.

It will now be shown that these total production weights required from each section of the mill, determine the exact number of spindles and sliver deliveries that are required.

1. A total capacity of 110,000 mule spindles was laid down as the fundamental basis.

2. $16836{\cdot}7 \times \frac{\text{counts.}\ 20}{30} = 11224{\cdot}4$ no. of fine jack-frame spindles.

3. $16921{\cdot}3 \times \frac{\text{hanks per spindle.}\ 6{\cdot}25}{38} = 2782$ total no. of roving-frame spindles.

4. $\frac{17006 \times 2{\cdot}5}{50} = 850$ total intermediate spindles.

5. $\frac{17091{\cdot}4 \times 1}{54} = 316{\cdot}5$ total no. of slubbing spindles.

6. $17264 \div 330 = 52{\cdot}3$ no. of finishing deliveries of draw-frames.

7. $17438{\cdot}3 \div 320 = 54{\cdot}4$ combers required.

8. $21797{\cdot}8 \div 2500 = 8$ or more of ribbon lap machines.

9. $22073 \div 2500 = 8$ or more of Derby doublers wanted.

N.B.—2500 lb. per week of $56\frac{1}{2}$ hours for this fine counts is perhaps rather a high production.

10. $22353 \div 270$ lb. $= 82{\cdot}7$ number of cards required.

11. One bale-breaker and one opener.

12. Two scutchers.

In fixing the amount of opening and scutching machinery regard must be had to their restricted productions due to the light weight per yard of the laps.

Drafts.

If we decide, as per table of particulars before given, that we require the counts from each machine to be fixed schedule, then the drafts must be found by calculation as below :—

1. $\frac{120 \times 2}{20} = 12$ draft.

The 2 above the line in this and other draft items is for placing two ends together behind the machine.

This 12 draft is on the low side for 120's, but the conditions will permit distinctly finer counts without altering the hank roving in the creels, by using more draft. Carriage "gain" and "ratch" or second stretch would reduce the amount of roller draft required distinctly for these counts.

Doubling roving is used invariably for either these counts or considerably lower.

It must be noted that this mill is being set out for four passages

of fly-frames, whereas there are firms who would spin 120's with only three passages of fly-frame, in which latter case the mule draft would probably be greater and the hank roving rather lower.

The fourth fly-frame permits the use of smaller drafts, more gradual drafting and finer hanks in the mule creels, all tending towards a better yarn. There is difference of opinion as to whether three or four passages of fly-frame are better for such numbers, but the four fly-frame method is the more costly.

Making the laps extremely thin and of light weight per yard at opener or card, adds to the danger of thick and thin places and uneven weights per yard.

2. $\frac{20 \times 2}{6{\cdot}25} = 6{\cdot}4$ draft at fine jack frame.

3. $\frac{6{\cdot}25 \times 2}{2{\cdot}5} = 5$ draft at roving frame.

4. $\frac{2{\cdot}5 \times 2}{1} = 5$ draft at intermediate.

5. $1 \div {\cdot}240 = 4{\cdot}16$ draft at slubber.

6. Without calculation the draft at the ribbon machine might be fixed at 6 or equal to number of doublings. The sliver lap machine draft is always low and could be fixed at $1\frac{3}{4}$.

The drafting at the comber is somewhat complicated by the working draft being affected by the number of doublings, and still more by the large percentage of comber waste.

The draft found by the connected wheels is totally different from, and much greater than, the real working draft found by dividing the weight of 1 yard of sliver into 1 yard of back lap. In this case we must put in as much draft as may be required to produce ·225 counts or hank of sliver. There is a convenient feed change wheel on every Heilmann comber, the amount of cotton fed per nip being increased in proportion to the increase in feed wheel teeth.

When we compare counts fed to a machine with counts delivered therefrom, and with draft put into a machine, we may remember that waste loss makes delivered counts finer.

7. *Draft at Carding Engine.*—The counts or weight per yard of lap = 10 oz. = $437{\cdot}5 \times 10 = 4375$ grains.

The chief counts dividend for cotton is as follows :—

Divide the constant $8{\cdot}\dot{3}$ by weight in grains of 1 yard.

$$\frac{8{\cdot}\dot{3}}{\text{Weight in grains}} = \frac{8{\cdot}\dot{3}}{4375} = {\cdot}0019 \text{ counts of scutcher lap.}$$

and $$\frac{{\cdot}250 \times 96}{{\cdot}0019 \times 100} = 126{\cdot}3 \text{ card draft.}$$

The opener and scutcher would be regulated in draft to give a scutcher lap weighing 10 oz. per yard.

Speeds of Spindle.

1. *Slubber.*—

(*a*) $\frac{54 \times 840 \times 36}{50 \times 60}$ = 545 inches per spindle per minute.

(*b*) $\sqrt{1} \times \cdot 75 \times 545 = 408\frac{3}{4}$ r.p.m. of slubber spindle.

2. *Intermediate Frames.*—

(*a*) $\frac{\overset{\text{yards per hank.}}{50} \times \overset{\text{inches per yard.}}{840} \times 36}{50 \times 60}$ = 504 inches per minute per spindle.

(*b*) $\sqrt{2 \cdot 5} \times \cdot 75 \times 504$ inches = 604·8 r.p.m. for intermediate spindles.

(hours per week. / mins. per hour.)

3. *Roving Frames.*—

(*a*) $\frac{38 \times 840 \times 36}{50 \times 60}$ = 383 inches per spindle per minute at the roving frame.

(*b*) $\sqrt{6 \cdot 25} \times \cdot 75 \times 383 = 718$ r.p.m. for roving spindles.

Fine Jack Frame.—

(*a*) $\frac{30 \times 840 \times 36}{50 \times 60}$ = 302·4 inches per minute per spindle.

(*b*) $\sqrt{20} \times \cdot 75 \times 302 \cdot 4 = 1013\frac{3}{4}$ r.p.m. of jack-frame spindle.

Mule Spindles.—

(*a*) $\frac{18 \times 840 \times 36}{52 \cdot 5 \times 60}$ = 172 inches per minute per mule spindle.

(*b*) $\sqrt{120} = 10 \cdot 95$.

(*c*) $10 \cdot 95 \times 2\frac{3}{4} = 30 \cdot 11$ twists per inch put in the yarn.

(*d*) $30 \cdot 11 \times 172 = 5178 \cdot 02$ revolutions of mule spindle actually to be made.

It was assumed that twelve seconds per minute were lost in backing-off and taking-in, so that the rate per minute of spindle revolution will be increased proportionately in order to get 5,178 actual revolutions or twists.

$5178 \cdot 02 \times \frac{5}{4} = 6468 \cdot 65$ r.p.m. rate per minute for spindle.

Example 2.

A mill to contain 100,000 mule spindles to spin 80's carded weft from Egyptian cotton.

Preliminary Data Adopted.

Machine.	Counts.	Weekly Production.	Twist Constants.	Waste Per Cent.
Opener . . .	—	15,000 to 25,000 lb.	—	—
Scutchers . .	11 oz. per yard of lap	10,000 to 12,000 lb.	—	4
Cards	·230	350 lb.	—	2
1st draw-frames	·230	400 ,,	—	5
2nd ,, ,,	·220	400 ,,	—	—
3rd ,, ,,	·210	400 ,,	—	1 over all draw-frames
Slubbers . . .	1¼ hank	52 hanks per spindle	At all fly frames take	1
Intermediates .	4 ,,	52 hanks per spindle	$\sqrt{\text{counts}} \times 85$	½
Roving frames	14 ,,	38 hanks per spindle	$\sqrt{\text{counts}} \times 3{\cdot}183$	½
Mules	80's	24 hanks per spindle		1½

Take 6 ends up at feed of draw-frames.
Allow 25 per cent. loss at mules for backing-off and taking-in.
From foregoing assembled data ascertain :—

1. Total productions per week from each kind of machinery.
2. Total quantities of machines or spindles of each kind.
3. At fly-frames and mules allow 5½ hours per week for doffing and various stoppages in a working week assumed to be 55½ hours. Working weeks of 48 hours, or other variations from 55½, would be proportioned.
4. Find total draft at each machine or process.
5. Find the twist per inch at all spindle machines.

Total Productions for 80's *Carded Weft.*

1. $100{,}000 \times \frac{24}{80} = 30{,}000$ lb. from mules.

2. $30{,}000 \times \frac{100}{98{\cdot}5} = 30{,}456$ lb. from roving frames.

3. $30{,}456 \times \frac{100}{99{\cdot}5} = 30{,}609$ lb. from intermediates.

4. $30{,}609 \times \frac{100}{99{\cdot}5} = 30{,}762$ lb. from slubbers.

5. $30{,}762 \times \frac{100}{99} = 31{,}074$ lb. from draw-frames.

6. $31{,}074 \times \frac{100}{99} = 31{,}389$ lb. from cards.

7. $31{,}389 \times \frac{100}{95} = 33{,}038$ lb. from scutchers.

8. $33{,}038 \times \frac{100}{98} = 33{,}714$ lb. from opener.

9. $33{,}714 \times \frac{100}{95} = 35{,}118$ lb. from mixings.

Quantities.

1. Mule spindles as planned 100,000.

2. $\frac{30456{\cdot}8 \times 14}{38} = 11{,}220$ roving-frame spindles.

3. $30609 \times \frac{4}{52} = 2354$ intermediate spindles.

4. $30762 \times \frac{1{\cdot}25}{52} = 740$ slubbing spindles.

5. $31074 \div 400 = 78$ finishing draw-frame deliveries.

6. $31388 \div 350 = 90$ cards with about 2 cards extra for grinding.

7. One bale breaker.

8. Two openers and four scutchers would be a likely service for above machinery, but this is subject to some difference of opinion.

Drafts.

Mule Draft.—

1. $\frac{80 \times 2}{14} = 11{\cdot}42$ total mule draft.

The carriage draft divided into the total would give the roller draft, which might be slightly increased to allow for twisting contraction.

2. $\frac{14 \times 2}{4} = 7$ roving-frame draft.

3. $\frac{4 \times 2}{1{\cdot}25} = 6{\cdot}4$ intermediate draft.

4. $1{\cdot}25 \div {\cdot}210 = 5{\cdot}95$ slubber draft, or

4*a*. If we desire to take the finished sliver at ·23 hank like the card hank we get as below

$$1{\cdot}25 \div {\cdot}23 = 5{\cdot}43.$$

5. $\frac{{\cdot}21 \times 6}{{\cdot}23} = 5{\cdot}43$ draw-frame draft, if finished sliver be taken at ·21. About 6 with both at ·23.

6. *Card Draft.*—

(*a*) $11 \times 437{\cdot}5 = 4812{\cdot}5$ grains in 11 oz.

(*b*) $8{\cdot}3333 \div 4812{\cdot}5 = {\cdot}00174$ counts of lap.

(*c*) $\frac{{\cdot}23 \times 95}{{\cdot}00174 \times 100}$ = draft in card = 125·6.

The reasoning of the last calculation is as follows :—

If 4812·5 grains = 1 yard, how many yards will 7,000 grains equal? Then divide by 840 to get hanks in 1 lb.

$$7000 \div 840 = 8{\cdot}\dot{3} \text{ constant number.}$$

Draft in openers and scutchers, $3\frac{1}{2}$ to $4\frac{1}{2}$.

Speeds for 80's.

Mules.—

(*a*) Twist per inch = $\sqrt{\text{counts}} \times 3{\cdot}183$
$= 8{\cdot}944 \times 3{\cdot}183 = 28{\cdot}468$, say $28\frac{1}{2}$ turns.

(*b*) $\frac{\overset{\text{hanks to yds.}}{24} \times 840 \times \overset{\text{to ins.}}{36}}{\underset{\text{hours}}{50} \times \underset{\text{mins.}}{60}} = 241{\cdot}9$ inches per minute given to each spindle.

(*c*) $241{\cdot}9 \times 28{\cdot}468 = 6{,}882$ actual r.p.m., to be made by spindles, allow 25 per cent. for loss in backing-off and winding-on.

$$6882 \times \frac{4}{3} = 9176$$

= rate of speed such as might be shown by a tachometer or be obtained by ordinary speed calculation.

Roving Frames.—

(*a*) $\sqrt{14} \times {\cdot}85 = 3{\cdot}17.$

(*b*) $\frac{38 \times 840 \times 36}{50 \times 60} = 383$ inches delivered per minute.

(*c*) $383 \times 3{\cdot}17 = 1214$ r.p.m. of spindles.

Intermediate Frames.—

(*a*) $\sqrt{4} \times \cdot 85 = 2 \times \cdot 85 = 1 \cdot 7$ turns per inch put in roving.

(*b*) $\dfrac{\overset{\text{hanks}}{52} \times \overset{\text{to yds.}}{840} \times \overset{\text{to ins.}}{36}}{50 \times 60} = 524$ inches delivered per minute.

$\overset{\text{hks. per week per spindle.}}{50} \times \overset{\text{mins. per hour.}}{60}$

(*c*) $524 \times 1 \cdot 7 = 891$ r.p.m. of spindles.

Slubbing Frames.—

(*a*) $\sqrt{1 \cdot 25} \times \cdot 85 = 1 \cdot 118 \times \cdot 85 = \cdot 950$ turns per inch.

(*b*) $\dfrac{52 \times 840 \times 36}{50 \times 60} = 524$ inches per spindle per minute.

(*c*) $524 \times \cdot 950 = 497 \cdot 8$ r.p.m. of spindles.

Placing the Machinery.

In England, the best practice is to put all the scutching and card-room machinery on the ground floor and the spinning-rooms above. This frequently necessitates the building of an extra shed to the ground floor, in order to accommodate a sufficient amount of card-room machinery. To take as an example, a modern mill arranged to spin fine numbers, the ground plan is somewhat as follows :—

The scutching-room and the boiler-house are at one end of the mill, being, of course, well separated from each other, and having the engine-house and the rope race between them and the large card-room and shed. From the scutching-room there is easy access round the corner of the wall containing the rope race into the card-room. Over the scutching-room is the cotton-room, where the cotton is put down the feed trunks of the openers. In many modern cases the cotton mixing room is placed *below* the blow-room, and the cotton lifted upwards by double lifting lattices, or else by means of exhaust feed pipes. The basement position of mixing-room, and bale-room facilitates unloading of bales, reduces fire risk, and more fully utilises the basement or cellar space of the mill. The laps from the openers are passed through the scutchers, which are arranged conveniently for handling the cotton, and the laps from the scutchers are conveyed to the cards. The sliver lap machines and the combers are arranged next to the cards, and the draw-frames conveniently to the combers. From the draw-frames the cotton is passed on to the slubbers, which are close by the intermediate frames, and the roving frames following closely on and being quite adjacent. The bobbins from the roving frames are quickly conveyed on bogeys running upon slips to a hoist, and taken up to the

spinning-rooms, where again there are slips for the bogeys to run upon to the proper pair of mules.

Ring Doubling Mill.

To produce 6,000 lb. of fine gassed yarns, 100's to 200's two-fold, per 56½ hours, with preparing and bundling.

Specification of Machinery.

9 Hill & Brown winders, 100 drums.
65 ring doublers, 364 spindles each, 2¼-inch gauge, 1½-inch and 1¼-inch ring, 4-inch lift.
10 Hill & Brown cross winding and clearing frames, 100 drums, 5-inch traverse.
10 gassing frames, 150 lights, 5½-inch gauge.
30 double 40 hank reels, 3½-inch gauge.
26 yarn preparing machines.
3 10 lb. bundling presses.

Card-Room Plan.

In a mill not using combers the cards might extend all down one long side of the ground floor, and the roving frames down the opposite long side of the same floor; between the two may be the draw-frames, slubbers, and intermediates, set lengthways, or end to end with the roving frames.

The Blow-Room.

Take a mill of about 80,000 spindles spinning, say, average 42's counts of American cotton. One method is to have for these conditions two opener and lap machines combined, four intermediate and four finisher scutchers. The openers are often fed by means of exhaust trunks from the room above. Each opener is placed behind two scutchers, and may be placed more particularly behind either the inside or outside one of each pair of scutchers, just as may be deemed most convenient. The four finisher scutchers are placed immediately in front of and in a line with the intermediate scutchers. These positions facilitate the transference of cotton from one machine to another with a minimum expenditure of labour, besides making the arrangement to appear symmetrical.

The Crighton type of opener is popular for medium counts of yarn as made by one or other of the various machinists. Most of the latter—whilst having some special form of beater of their own—also make large numbers of the Crighton. One of its chief merits is that it exercises a kind of discriminatory action upon the cotton,

operating more upon heavy or tangled masses of cotton than upon lighter and more open portions. This is largely due to the fact that the cotton has to be lifted upwards by the action of an air current induced by a powerful fan. There are other openers which are specially designed for the better classes of cotton, as it is considered that the action of the Crighton is too rough for these cottons, but there is some difference of opinion on this point.

Fig. shows the plan of a blowing-room fitted with one exhaust opener and four scutchers. The cotton enters through the trunk, B, and passes through the opener, D. This opener keeps the two breaker scutchers at A going. Each breaker at A keeps a finisher going at C. Such an arrangement would serve for, say, a mill of 45,000 spindle spinning average about 45's single roving American cotton. As against ten or twelve machines in the blow-room of a mill of 100,000 spindles, it is stated that one recent American mill has

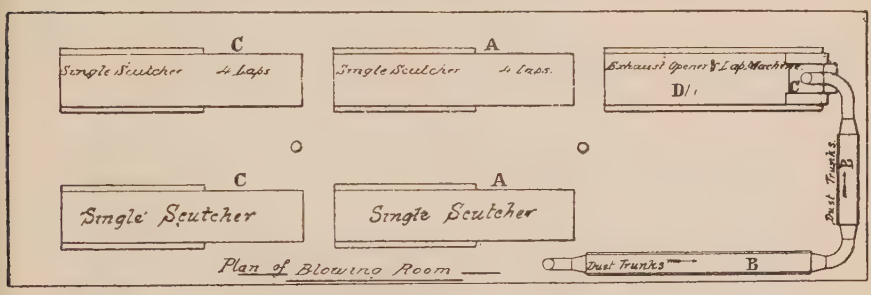


Fig. 134.

thirty-two machines all in one blow-room, for a matter of 250,000 spindles.

The Card-Room.

It is now the usual practice to place all the card-room machinery on the ground floor for two or three reasons :—

(1) Steady running of the machinery with a minimum amount of vibration is secured. (2) The handling of the cotton in its passage from one process to another is much facilitated. (3) When all the card-room machinery is on one floor the supervision of the machines by the carders, over-lookers and managers is rendered easier.

This placing of all the card-room machinery on the ground floor constitutes one of the most important modifications ever made in the planning out and arrangement of cotton spinning mills, and dates as far back as 1885 for its introduction.

The blowing-room should be always separated from the card-room on account of the great danger of fire in the openers and scutchers, and also because of the dirtier and dustier nature of the opening processes and the heavy driving required for the machinery.

The blow-room should always be fitted with iron doors, or composite fire-proof doors, which can be readily closed in case of fire.

Apart from these considerations it is advisable to have the blow-room as convenient to the card-room as possible, on account of the laps having to be carried from the scutchers to the cards, or else moved about on special waggons or long trucks, which will curve round a corner.

The two rooms are best when on the same floor, although this advantage does not always exist. There should be a passage between the two rooms, of sufficient length, and iron or composite doors for shutting in case of fire, and the floor should be in all cases fire-proof.

Fig. 132 shows the plan of a card-room fitted up by Messrs. Dobson & Barlow, while Fig. 133 shows the fourth floor of the same mill, this room and others being filled with mules.

A Specification Example.

You have to order the machinery for a mill to spin counts from 40's to 50's, say 40,000 lb. weight of twist and 10,000 lb. weight of weft on mules. The building is 100 feet wide, and you can allow for alleys 5 feet, and for gearing and ends of machines as follows: drawing frames (straight beams three heads), 7 feet 6 inches; speed frames, 3 feet each; mule, 5 feet 3 inches. The cards are made with cylinders 40 inches wide, 50 inches diameter. Say (*a*) at what speed would you run the various machines, beginning at the card to get the production; (*b*) how many cards you would use; (*c*) how many drawing frames, giving gauge, number of heads and deliveries; (*d*) number, lift and gauge of spindles in slubbing, intermediate, and roving frames respectively; (*e*) number of spindles in each mule, giving gauge. What weight of finished scutcher lap would you require to feed the card to get the total weight of finished yarn named?

Full working week 56½ hours, less stoppages. Each card may be assumed to produce 800 lb. of sliver per week; each draw-frame delivery, 820 lb.; slubbing spindle, say, fifty hanks per week; each intermediate spindle, fifty hanks; each roving spindle, forty hanks. The doffer of the card may be taken at about 14 r.p.m.

$$\frac{50{,}000}{800} = 62\tfrac{1}{2} \text{ cards,}$$

with two or three added for loss in waste.

$$\frac{50{,}000}{820}$$

say sixty finishing draw-frame deliveries, with two or three added for waste. There would be three heads or passages, giving a total of the above deliveries multiplied by three. Gauge of spindles may be taken at slubbing, 8 inches between centres of adjoining spindles in front row; intermediate, $6\frac{1}{2}$ inches; roving, 5 inches; twist mules, $1\frac{3}{8}$ inch; and weft mules, $1\frac{1}{8}$ inch. Lifts may be taken at slubber, 10 inches; intermediate, 9 inches; and roving, 8 inches. The number of spindles in the bobbin and fly-frames would be got by dividing the hanks per spindle into the total hanks required to be produced by the frames, and the spindles per frame would be divided out to suit the special conditions, and the same may be said of the mules.

Machine Drafts.

Schemes of drafts to produce (*a*) 20's hosiery yarn, (*b*) 50's weft, (*c*) 100's combed Sea Islands. With weight of card lap in each case.

For 20's hosiery the card sliver might be taken, say, at ·15 hank sliver, and the weight of lap fed to the card at about 14 oz. per yard. At the draw-frame we might put six ends up together, and there would in all probability be a total draft of about six. The slubber might have a draft of five and produce a $\frac{3}{4}$-hank slubbing, although many people would only have a $\frac{5}{8}$ slubbing for these counts even though it be for hosiery. Assuming a draft of about five at the intermediate and two ends up, we should then have a draft of about six at the rover with two ends up so as to produce a $5\frac{3}{4}$-hank roving. As hosiery yarn requires to be usually soft spun we are favouring the spinning by giving a comparatively fine hank rove for 20's, and using double roving at the spinning machine. We, therefore, get 20's with something like seven of a draft. The above hanks and counts are finer than would be for single roving. For 50's weft (Egyptian cotton), taking double roving at the mule, we may have a lap of $11\frac{1}{2}$ or 12 oz. per yard, a draft of about 115 in the card, giving about a ·2 hank sliver, six ends up at the draw-frame; slubber, making one hank slubbing with a draft of about 4·6; on intermediate, a draft of six with counts of almost three; on rover, a 9-hank roving with a draft of about 6·5; on mule, a draft of about eleven. 100's combed Sea Islands: We might start with a lap of about $9\frac{1}{2}$ oz. per yard, and from the card produce about a ·28 hank sliver with a draft of, say, 135 to 140; draw-frame, six, seven or eight ends up, optionally, with draft in proportion; at slubber, a draft of 4·3, producing a 1-hank and having four passages of fly-frames;

intermediate, 4·5 draft with $2\frac{1}{4}$ hank; rover, about 5 draft and $5\frac{1}{4}$ hank, fine Jack draft of 6 and hank of 16; at mule, a draft of about 12 or 13. The comber might produce a sliver the same counts or a little coarser than card with total draft of about 30 and effective draft of 5 or 6 as comparing 1 yard of back lap with 1 yard of delivered sliver. In a specific test 6 yards of sliver weighed 288 grains or 48 grains per yard, while 1 yard of back lap weighed 322 grains; $322 \div 48 = 6{\cdot}6$ effective draft, allowing for waste per cent. as well as mechanical or wheel draft, which would reach 50 or so, but neutralised by 8 laps put up together.

Mill to Spin Mixed Counts.

The setting-out of a mill spinning a wide range of counts, say from 20's to 50's, two-thirds of the production being from 26's to 32's. Kind of machines to select, and how to arrange as to lifts of bobbins and other details.

Since the bulk of our production has to be from 26's to 32's, with a smaller amount of yarn ranging down to counts 20's and up to counts 50's, it will be convenient to take a basis of, say, 30's average counts. For these counts the following particulars would be suitable, taking a mill of, say, 42,000 spindles, producing 1 lb. per spindle per week, of 30's average counts, in a working week of $56\frac{1}{2}$ hours, less stoppages.

One bale breaker would pull the requisite amount of cotton easily, and should be coupled up to properly disposed mixing lattices.

We might allow two openers, fitted with hopper feeds and large beaters, either of the Crighton or the cylindrical type, as either would do very well for this class of cotton. In many cases there would be three intermediate and three finisher scutchers for American cotton, but some people would now dispense with the intermediate scutchers. The finisher scutcher may make a lap of $13\frac{1}{2}$ oz. per yard.

The cards would be of the revolving flat type, and would work well with a draft of 100, producing, say, 750 lb. of sliver per week per card. The hank sliver might be, say, ·160. It is not likely that the combing series of machines would be used. The drawframes might have a draft of six or less with six ends up, producing about 800 lb. per delivery. Three passages of fly-frames. The lifts might be slubber, 10 inches; intermediate, 9 inches; rover, 7 inches. Whether the mill would be all rings, all mules, or a proportion of each, would depend upon circumstances, but any of the three would be possible. We might have a $\frac{5}{8}$ slubbing, a $1\frac{1}{2}$ intermediate, and a 4-hank roving. These hanks are for single roving

at the spinning machine. In each case a working week of 56½ hours is assumed although the present week is 48 hours.

Assume that you were starting a mill for spinning: 26's ring twist, 36's twist and 40's weft. How to arrange the drafts of the various machines, beginning with the carding engine, working week 56½ hours.

We will start with a lap which weighs 14 oz. to the yard, and then for 36's we might have the following drafts: Card, 100; at each head of drawing, 6; slubber, 3·88; intermediate, 5·25; roving, 6·5; mule, 8.

A 14 oz. lap = ·00136 hank lap, as shown below:—

$$\frac{8{\cdot}3333}{14 \times 437{\cdot}5} = {\cdot}00136.$$

Then proof of drafts

$$= \frac{{\cdot}00136 \times 100 \times 6 \times 6 \times 6 \times 3{\cdot}88 \times 5{\cdot}25 \times 6{\cdot}5 \times 8}{6 \times 6 \times 6 \times 2 \times 2} = \text{about } 36\text{'s}.$$

For the 40's weft we might maintain all the same dimensions, excepting that we have a 5·15 draft at the intermediate and a 4·5 draft at the slubbing frame.

Proof:—

$$\frac{{\cdot}00136 \times 100 \times 6 \times 6 \times 6 \times 4{\cdot}5 \times 5{\cdot}15 \times 6{\cdot}5 \times 8}{6 \times 6 \times 6 \times 2 \times 2} = 40\text{'s}.$$

A better plan for getting the 40's weft than the foregoing would be to maintain the first-named dimensions as given for the 36's as far as the roving, and then put a little extra draft on the roving frame, and serve the weft mules with a little finer hank bobbin than the twist. In some cases it would be quite as useful and more economical to maintain all the conditions given for 36's up to the spinning-room, and to get the 40's weft by putting a little more draft than 8 into the mules. In any case it must be distinctly understood that in actual practice none of the dimensions given are hard and fast rules, as we should seldom find two mills exactly alike in all particulars. Some men would put a less draft in the slubber because of the stuff being so soft and thick. Frequently the draft is changed somewhat at some of the machines to make the stuff thicker or thinner according to the wrapping. Often the drafts are changed in some of the machines in order to make them turn off a greater or less weight of cotton, as the case may be, and this has to be counteracted by altering the draft elsewhere in order to keep the finished counts at the same thing. Often a different weight of lap would be adopted than 14 oz. to the yard, and this would have to be counteracted in some of the machines by altering the draft. Some mills, for instance, would adopt a lap 12 oz., or,

say, 12·75 oz. to the yard for the counts under discussion, which would equal respectively ·0016 hank lap and ·0015 hank lap. This with a draft of 100 in the card would give respectively ·16 hank sliver and ·15 hank sliver. In order to obtain the correct finished counts of yarn in either of these cases, 1 or more of the drafts in the subsequent machines would have to be made less than as given for the 14 oz. lap.

Drafts Continued.

Drafts to spin (*a*) 24's ring-frame twist from a 15 hank sliver of Indian cotton, omitting the intermediate frame ; (*b*) 40's weft from a ·16-hank sliver, good middling American ; (*c*) 100's twist from a ·19-hank sliver, from Egyptian cotton, with and without a jack frame.

For 24's Twist :—

$$\frac{24}{\cdot 15} = 160 \text{ total draft without doubling.}$$

Allowing two ends up at the roving frame only, we get $160 \times 2 = 320$ total draft.

We may assume 5 draft at slubber and 7 draft at roving frame. Then—

$$\frac{320}{5 \times 7} = 9{\cdot}14 \text{ draft at ring-frame.}$$

For 40's Weft :—

$$\frac{40}{\cdot 16} = 250 \text{ total draft without doubling.}$$

Assuming doubling at intermediate and roving frames and single at the mule, we get $250 \times 2 \times 2 = 1{,}000$ total draft.

We will assume drafts as below :—

At the slubbing frame	4·5
At the intermediate frame . . .	5·5
At the roving frame	6·5

$$\frac{1{,}000}{4{\cdot}5 \times 5{\cdot}5 \times 6{\cdot}5} = 6{\cdot}2 \text{ draft at mule ;}$$

or better results would be got from the following :—

At the slubbing frame	4
At the intermediate frame . . .	5
At the roving frame	6

$$4 \times 5 \times 6 = 120,$$

and

$$\frac{1{,}000}{120} = 8{\cdot}3 \text{ draft at the mule.}$$

For the 100's *Twist without Jack Frame.*—

Assume at the slubbing frame . . 6
Assume at the intermediate frame . 7
Assume at the roving frame . . . 8

Then $6 \times 7 \times 8 = 336$.

Assuming double roving at the intermediate, the rove and the mule, we get

$$\frac{100 \times 2 \times 2 \times 2}{19} = 4{,}210 \text{ total draft.}$$

Then

$$\frac{4{,}210}{336} = 12{\cdot}5 \text{ draft at mule.}$$

For 100's *Twist with the Jack Frame.*—The total draft will be then $4{,}210 \times 2 = 8{,}420$. Let the drafts at the four fly-frames be 4, 5, 6 and 7 respectively.

Then

$$\frac{8{,}420}{4 \times 5 \times 6 \times 7} = 10 \text{ draft at mule.}$$

Ring Spindle Mill.

Assume you have 35,000 ring spindles producing 14 oz. per week each of 40's yarn. Find number of preparing machines, speeds of spindles, and productions on a working week of $56\frac{1}{2}$ hours, less stoppages.

Before we can proceed to ascertain the number of machines required it will be necessary to lay down certain particulars as a working basis. Such particulars are given in the table below, but it must be understood that in different mills very different particulars are sometimes worked upon.

TABLE.

Machine.	Counts.	Production.	Waste Per Cent.
Card	·16	800 lb.	5
Draw-frame delivery .	·16	800 ,,	1
Slubber . . .	$\frac{3}{4}$	50 hanks per spl.	$\frac{3}{4}$
Intermediate . .	$1\frac{1}{2}$	48 ,, ,, ,,	$\frac{1}{2}$
Roving frame . .	5	40 ,, ,, ,,	$\frac{1}{2}$
Ring frame . .	40's from single roving		2

$$\frac{35{,}000 \times 14}{16} =$$

30,625 lb. of yarn produced from the mill.

$$\frac{30{,}625 \times 100}{98} =$$

31,250 lb. of cotton from roving frame.

From this point we will take the waste inclusive to the cards, although this is not a strictly correct method :—

$$\frac{31{,}250 \times 100}{97{\cdot}25} =$$

32,133 lb. of sliver from the card.

$$\frac{31{,}250}{40} = 781 \text{ roving spindles.}$$

It will be near enough for our purpose to assume the same production from the intermediates and slubbers as from the roving frames, and the same production from the drawings as from the cards :—

$$\frac{31{,}250}{48} = \text{intermediate spindles,}$$

$$\frac{31{,}250}{50} = \text{slubber spindles,}$$

$$\frac{32{,}133}{800} = 40 \text{ cards,}$$

and the same number of finishing draw-frame deliveries. We might say that for this quantity of yarn we should require :—

1 bale-breaker,
1 opener,
2 finisher scutchers,
2 breaker scutchers.

For a working week of 48 hours take for productions the proportion $56\frac{1}{2}$ is to 48, other productions for greater or less periods, to be also taken in proportion.

As regards speeds of spindles we might say :—

8,500 for the ring-frame,
1,050 ,, ,, roving frame,
760 ,, ,, intermediate frame,
570 ,, ,, slubber frame.

Arrangement of Machinery.

We may describe the arrangement of spinning machines in a mill producing from 30's to 40's yarn two-thirds twist (*a*) on mules, (*b*) on ring-frames. Say (1) the number of spindles and gauge of machines; (2) if any difference in the arrangement of the line

shafts is necessary in the two cases; (3) if any variation would be needed in the number and size of the preparatory machines.

In the case of the spinning-room filled up with mules the latter might extend across a wide mill, say 126 to 130 feet wide, including alleys and there is usually in such a case one line shaft extending over the mule creels, at right angles thereto, for the full length of the room. Such a line shaft may be placed 6 to 8 yards away from the nearest mule headstock, in order to give a sufficiently long top belt.

In the case of a room being filled up with ring-frames, there might be two lines of ring-frames in the width of the room, and in most cases there would be a line shaft to each line of frames. In some cases the line shafts are placed over the ends of the frames and half-crossed belts are used while in other cases the line shafts extend over the creels, and gallows pulley driving is adopted.

The gauge of spindle for the twist mules would be probably $1\frac{3}{8}$ inch, and for weft $1\frac{1}{8}$ inch.

The space or gauge for the ring-frame spindles might be $2\frac{5}{8}$ inches for twist and, say, $2\frac{1}{4}$ inches for weft. For these counts, 30's to 40's, we might take each ring spindle to equal, say, $1\frac{1}{4}$ to $1\frac{1}{2}$ mule spindles, and the number of preparatory machines would have to meet this difference.

Reference Tables for Cotton, Counts, and Drafts.

FOR 5's/8's PREPARATION YARNS—SYSTEM 1.

Machine.	Cotton.	Draft.	Counts.
1. Opener . .	Mixtures of Indian, low American, strips, and fly	3	1 lb. per yard
2. Single roller and clearer card with side drawing and single delivery . . .	—	50/60	·12 about
3. One or two draw-frames . . .	—	3 to 4	·12 about
4. Slubber . .	—		$\frac{3}{8}$'s/$\frac{1}{2}$'s
5. Roving frame with 8 in. lift or else intermediate with 9 in. lift to go direct to mule creel . . .	For 5's the slubber bobbins may be short lift and go directly to mule creel	4 double roving about 5	$1\frac{1}{8}$/$1\frac{1}{2}$
6. Mule of wide spindle gauge 3 lines of small diameter rollers. Very long spindles . . .	—	5/7 draft from single roving. 48 hour week.	5's/8's counts of yarn weekly production from pair of mules 2500/4000 lb.

N.B.—These tables are for reference only, and in every mill application would be varied to suit the individual case.

The yarn spun as above could be sold in cop, or reeled and bundled, or put through the winding and beam warp machines.

PREPARATION SYSTEM 2.

Machine.	Cotton.	Draft.	Counts.
1. Willow . .	The chief question in regard to raw material would be whether to use cop bottom or other hard waste. A choice could be made, according to state of cotton and yarn markets, between Indian or low American new cotton, strips, comber waste, or even a proportion of best condenser fly.	—	—
2. Cop bottom machine, with soaper if hard waste is used, or else		—	—
3. Crighton opener for dirty soft waste or low class new cotton .		—	—
4. Single scutcher with hopper feed .		3	lap weight 1 lb. per yard
5. Single breaker roller card . . .		card drafts 50/60	—
6. Derby doubler .		40/60	$1\frac{1}{8}$ to $1\frac{1}{4}$
7. Single roller finisher card with quadruple coiler (4 cans)		× 4 by the four coiler system	
8. Slubber (no drawframes)		$2\frac{3}{4}/3\frac{1}{2}$	3 to 4 hank
9. Mule or ringframe with creel for slubbing bobbins and three lines small diameter rollers . .		$2\frac{1}{2}$ to $4\frac{1}{2}$	7's to 15's

NOTE.—Compared with the condenser system, the preparation system gives a yarn of greater strength and the capacity for finer counts from same cotton mixing, because of the use of draft rollers. The yarn, however, is not near so full, soft, or level "looking" as condenser yarn, and does not give the same woollen-like appearance or feel. Preparation yarn may be used as a weft in cloths to be printed or dyed, such as towels and cretonnes, and also it is sometimes used in woven belting and in making ropes and banding.

For 10's to 14's Yarn.

The qualities of about 10's counts of yarn vary greatly according to requirements.

Sometimes from Egyptian or American cotton from double roving for a strong quality of hosiery. More usually single roving.

Sometimes in fine condenser yarns for flannelettes and similar goods. At other times in preparation yarns.

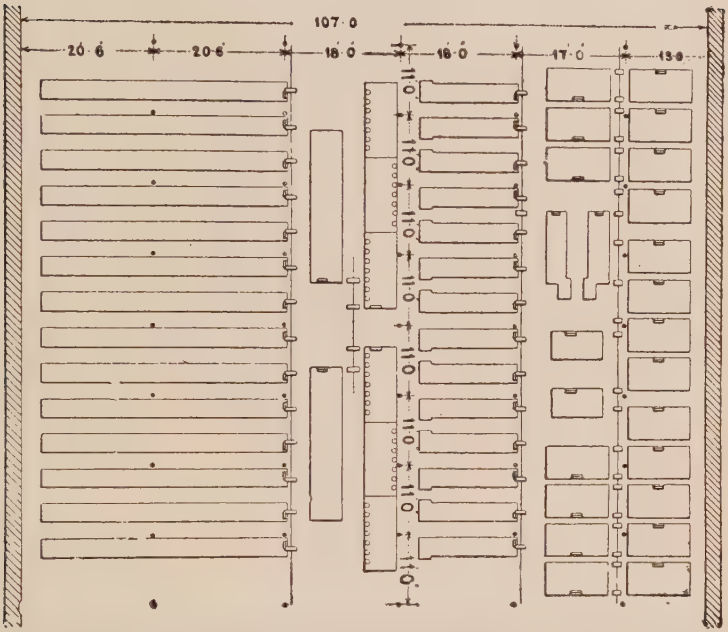


FIG. 135.—Plan of card-room for a very small spinning mill for fine counts, 80's combed, 20 cards, 2 sliver lappers, 2 ribbon lappers, 14 combers, 3 passages of draw-frame with 14 finishing deliveries, 2 slubbers, intermediates, and roving frames as shown.

Machine.	Cotton.	Draft.	Counts.
Bale-breaker . .		—	—
Crighton opener with hopper feed . .	Either a fair class	3/4	—
Scutcher . . .	of Indian cotton or a moderate quality of	3/4	lap, 13/14 oz. per yard
Carding engine . .	American, or a fair	about 90	about ·136
Draw-frames . .	class of Chinese, ac-	6	·136
Slubbing frame .	cording to district and	about $3\frac{1}{2}$	about 1/2's
Intermediate frame .	circumstances.	$3\frac{3}{4}$ to 4	1
Roving ,, .	Possibly comber	4 to 5	$2\frac{1}{2}$
Ring-frame or mule .	waste.	5 to 6	10's to 14's

In some countries the ring-frame is almost always chosen to spin these numbers, but in some English districts the mule is yet in favour for such yarns.

In some cases one fly-frame passage would be omitted and the several drafts slightly increased.

For 16's to 20's.

Machine.	Cotton.	Draft.	Counts.
Bale-breaker		—	—
Crighton opener with Hopper feed and blade beater	A good variety of Indian cotton, or a moderate quality of American, according to circumstances. Bobbin waste broken up, and used again in same mill. Comber waste.	—	—
Scutchers		3/4	13/14 oz. per yard of lap
Carding engines		90/95	·138
Draw-frames		equal to ends up	·138
Slubbing frames		3·5 to 3·7	$\frac{1}{2}$
Intermediate frames		about 4	1
Roving frames		$5\frac{1}{4}$ to $5\frac{5}{8}$	$2\frac{3}{4}$ to 3
Mule or ring-frame		6 to 7	yarn counts / roving counts approximate

For 30's to 36's.

Machine.	Cotton.	Draft.	Counts.
Bale-breaker		—	—
Any good opener		—	—
Scutcher	Chiefly from a fairly good class of American cotton, such as Texas or Memphis, the ring-frame probably requiring slightly better cotton than the mule. Oklahama, Tangiers, or Californian.	3/4	lap, 13 oz. per yard
Revolving flat cards		100	·170
Draw-frames, 3 passages		equal to ends up, probably 6	·170
Slubbing frame		4	$\frac{3}{4}$
Intermediate frame		$4\frac{3}{4}$ to 5	$1\frac{5}{8}$ or $1\frac{3}{4}$
Roving frame		about $5\frac{1}{4}$	$4\frac{1}{2}$ to 5
Mule or ring		$7\frac{1}{4}$ to 8	30's to 36's
Single roving			

Various particulars of drafts and counts are given in other pages for other ranges of yarns. Worked out examples and details for 80's carded weft, and 120's combed yarns are elsewhere given in this treatise.

60's Egyptian Twist (*for note to table see p.* 574).

Machine.	Cotton.	Draft.	Counts.
Hopper bale-breaker .	Sakeleradis of medium quality or other good average Egyptian cotton.	—	—
Cylindrical opener with either up- or down-stroke and with hopper feed .	—	3½ to 4½	—
Scutchers . . .	—	3 to 4	lap, 11 oz. per yard
Carding engine . .	—	125	·23
Draw-frames, 3 passages (sometimes 4)	—	equal to no. of ends up	·23
Slubbing frames .	single roving	4½ to 5	1⅛
Intermediate frames .	double ,,	5⅜ to 5¾	3⅛
Roving frames . .	double ,,	about 7	hank, 10¼ to 11½
Mules . . .	double ,,	11/11½	—

Counts 100's Single Combed from Egyptian Cotton.

Machine.	Remarks.	Draft.	Counts.
Bale breaker . .	From good Egyptian cotton chiefly.	Indifferent	—
Cylinder opener with hopper feeder .	4 laps behind scutcher, 18 slivers behind Derby doubler. Laps for Derby doubler, 1½ in. narrower than for comber to allow for spreading at ribbon machine.	3/4	—
Single scutcher . .		3/4	lap, 10 oz. per yard
Carding engines . .		135/140	·28
Sliver lap machine .		1¾ to 2	—
Ribbon lap ,, .		6 for 6 doublings	
Combers . . .	Sometimes an extra passage of draw-frame before the comber instead of the ribbon machine, but the latter method is the more up-to-date.	—	lap, 11½ to 13 dwts. per yd.
Draw-frames . .		8 ends up and 8 draft	Comber and draw-frame counts about ·23
Slubber . . .	Either Heilmann or Nasmith.	4·2	1
Intermediate frame .	Double roving at all spindle machines except slubber.	4·6	2¼
Roving ,, .		—	
Fine jack ,, .	In this case 4 passages of fly-frame are adopted, but sometimes only 3 are used for 100's yarn.	4¾	about 5½
,, mule . . .		about 6	16 to 17
		about 12	90's to 110's

N.B.—Sometimes 2 inches narrower width is made at sliver lap than at ribbon lap machine.

Note to 60's Egyptian Twist Table.

Both 6 ends up and 8 ends up behind the draw-frames are in use for these counts, but 6 ends up is the more used.

Suppose, for example, it was found after fully working for some time that the intermediate frames would scarcely keep up with the roving frames, and it was not convenient or desirable to get more intermediates; nor could they be speeded or kept going better.

A slight reduction in intermediate frame draft would feed a greater weight of cotton through, but must be rectified in counts by making slightly finer intermediate back bobbin, or slightly increasing roving frame draught.

Yet again, the average counts of yarn might go finer or coarser according to the market, thus upsetting the relative capacity of one set of machines to another. In such ways exact tabulated counts, drafts, and productions are subject to variation, unless one set of machines is occasionally stopped.

Approximate Particulars, 140's to 160's Double Combed from Sea Islands Cotton.

Machine.	Remarks.	Draft.	Counts.
Hopper bale-breaker, optionally used .	1. In this example the older system of	—	laps
Single cylinder opener	using an extra draw-frame before combing,	3 to 5	10 to 11 oz. per yard
Scutcher, optionally used . . .	is adopted, instead of the ribbon machine.	—	—
Carding engines .	2. Four passages of fly-frame.	—	sliver, about 22 grains per yard
Comber drawing head	3. The second combing is more for extra	6 ends up and 6 draft	—
First sliver lap machine . . .	parallelising, brightening, and impurity removing, rather than for	1½	sliver, about 22 grains per yard
First combing . .	short fibre extraction.	—	—
Second sliver lap machine . . .	So the first combing	1·15	light lap
	may extract 19/21 per cent. and second combing only 4½ to 6 per cent.		weight per yard
Second combing .		—	about 26 grs. per yard
Three heads of draw-frame . . .	4. Heilmann combers.	—	for sliver
	5. The fine yarn counts are obtained more by using 4 fly-frames rather than a		light laps, sliver, about 32 grs. per yard from draw-frame
Slubbing frame . .	very light lap behind	—	1
Intermediate frame .	the card. Also by light	5 to 5½	2½ to 3
Roving ,, .	comber slivers.	5½ to 6	7½ to 8½
Fine jack ,, .		6 to 7	24 to 27 hank
,, mule . . .		11½ to 13½	140's to 160's

Mill Producing 16's *Yarn.*

Assume a mill containing 40,000 mule spindles spinning 16's yarn, and half of them were substituted by ring spindles, possible

changes to be made in the preparation machinery. Extra ring-frame production would be $1\frac{1}{5}$ to $1\frac{1}{2}$ times per spindle.

It is very probable that the 20,000 ring spindles would turn off at least one-fifth part more weight of yarn than the 20,000 mule spindles for which they were substituted. This would increase the total production of the mill in 36's yarn something like as 8 is to 9, and would have to be met by a like increase in weight of rovings from the card-room. There are three principal ways in which this could be done. They are, first, by increasing the speed of the card-room machinery and allowing the counts at the various machines to remain untouched; secondly, by making the hank roving, hanks intermediate, hank slubbing, etc., coarser, and making a corresponding increase in the draft of the spinning machines, in order to get the 36's out finally; thirdly, by obtaining a sufficient amount of extra card-room machinery to meet the case.

As to which of these three we should put into practice, or whether we should meet the case with a blending of two of the three methods, or even all three, would depend upon local circumstances, the opinions of those in charge, space and money available for new machinery. As touching the first-named alterations, if our card-room machinery were already quite up to speed, common sense would teach us at once that our remedy would not be found there, but if, as might be the case, it was more or less under-speeded, we should naturally take advantage of that circumstance, and put the speed up. It would be an easy matter to speed most of the card-room machinery up by putting less pulleys on the main shafts of the various machines, although we should better avoid slippage of belts by making line shaft pulleys larger.

As regards making hank roving, etc., coarser, this would be contrary to what would be good practice in order to get good spinning and good yarn. On the ring-frame for the same counts of yarn many practical men will have a little finer hank roving than on the mule, because on the latter machine we have the principles of "drag" or "gain" to aid the "draft," while these principles are practically absent in the ring-frames, and indeed there is often yarn contraction and thickening due to twist.

The provision of more roving spindles, in the approximate proportion of as 8 is to 9, would be in most cases undoubtedly the best practice to follow, in order to meet the case in a properly balanced manner and to keep up the quality of the spinning and of the yarn produced. There would probably be room for extra frames by the ring spindles taking up less room than the same number of mule spindles, and it would be a matter for still further reflection as to what extent the machinery should be increased through which the cotton passes before reaching the roving frames.

Production of Ring-Spinning Frames.

Indian and American Cotton (Twist).

Counts.	Speed of Spindle.	Twist per Inch.	Hanks per Spindle in 10 Hours.	Lb. per Spindle in 10 Hours.	Hanks per Spindle per Week of 56½ Hours.
4	4523	8·00	9·12	2·28	51·57
6	5500	9·79	9·34	1·55	52·78
8	6400	11·31	9·54	1·19	53·90
10	7150	12·64	9·74	0·97	55·03
12	7500	13·85	9·31	0·77	52·59
14	8000	14·96	9·58	0·68	54·13
16	8500	16·00	9·51	0·59	53·73
18	8500	16·97	8·97	0·498	50·69
20	8500	17·88	8·67	0·43	49·00
22	8500	18·76	8·27	0·37	46·73
24	8500	19·59	7·90	0·329	44·67
26	9000	20·39	8·05	0·309	45·50
28	9000	21·16	7·76	0·277	43·84
30	9000	21·90	7·49	0·249	42·30
32	9000	22·62	7·25	0·22	40·96
34	9500	23·32	7·43	0·218	41·99
36	9500	24·00	7·23	0·20	40·85
38	9500	24·65	7·03	0·18	39·72
40	9500	25·29	6·84	0·17	38·69

Egyptian Cotton (Twist).

30	8500	19·75	7·85	0·26	44·36
32	8500	20·4	7·59	0·23	42·92
34	8500	21·02	7·37	0·21	41·68
36	8500	21·64	7·16	0·19	40·44
38	8500	22·23	6·97	0·18	39·41
40	8500	22·81	6·79	0·17	39·38
42	8500	23·37	6·75	0·16	38·17
44	8500	23·92	6·60	0·15	37·33
46	8500	24·45	6·46	0·14	36·49
48	8500	24·96	6·34	0·13	35·86
50	8500	25·50	6·31	0·12	35·68
52	8500	26·00	6·20	0·11	35·03
54	8500	26·50	6·07	0·11	34·28
56	8500	26·98	5·97	0·10	33·75
58	8500	27·46	5·86	0·10	33·11
60	8500	27·93	5·76	0·09	32·57

Production of Weft Ring-Spinning Frames.

12	6500	11·24	9·95	0·83	56·23
14	7000	12·15	9·91	0·708	56·00
16	7500	13·00	9·92	0·62	56·09
18	7500	13·78	9·36	0·52	52·88
20	7500	14·52	8·87	0·44	50·16
22	7500	15·24	8·81	0·40	49·78
24	8000	15·91	8·99	0·37	50·39
26	8000	16·57	8·62	0·33	48·77
28	8000	17·19	8·32	0·297	47·05
30	8000	17·77	8·05	0·268	45·53
32	8500	18·36	8·43	0·263	47·68
34	8500	18·94	8·18	0·240	46·26
36	8500	19·50	7·94	0·22	44·88
38	8500	20·02	7·74	0·20	43·74
40	8500	20·54	7·54	0·188	42·61

Diam. of Bottom Rollers for Different Cottons.

⅞ inch, ¾ inch, ⅞ inch Indian and Short American.
1 inch, ¾ inch, 1 inch } American.
1 inch, ⅞ inch 1 inch }
1 1/16 inch, ⅞ inch. 1 1/16 inch Egyptian.

Ring Spinning: Calculated Production for Ten Actual Working Hours of Frame.

Twist (Turns = $\sqrt{Counts} \times 4$).

Nos.	Diam. of Ring.	Gauge.	Turns Per Inch.	Diam. of F.R.	Revs. of F.R.	Inches Delivered Per Min.	Revs. of Spindles Per Min.	Hanks Per Spl. Per 10 Hours.	Lb. Per Spl. Per 10 Hours.	French Nos.
	In.			In.						
5	2	3	8·94	$\frac{7}{8}$	203·5	559·29	5000	11·09	2·21	4·23
	2	3		$\frac{7}{8}$	244·2	671·14	6000	13·31	2·66	
7	2	3	10·58	$\frac{7}{8}$	189·16	519·83	5500	10·31	1·472	5·92
	2	3		$\frac{7}{8}$	206·37	567·107	6000	11·252	1·607	
	2	3		$\frac{7}{8}$	223·5	614·36	6500	12·18	1·74	
10	$1\frac{3}{4}$	$2\frac{3}{4}$	12·64	$\frac{7}{8}$	172·74	474·7	6000	9·418	·9418	8·47
	$1\frac{3}{4}$	$2\frac{3}{4}$		$\frac{7}{8}$	194·32	534·01	6750	10·59	1·059	
	$1\frac{3}{4}$	$2\frac{3}{4}$		$\frac{7}{8}$	215·92	593·35	7500	11·77	1·177	
12	$1\frac{3}{4}$	$2\frac{3}{4}$	13·85	$\frac{7}{8}$	157·64	433·21	6000	8·595	·716	10·16
	$1\frac{3}{4}$	$2\frac{3}{4}$		$\frac{7}{8}$	183·9	505·41	7000	10·02	·835	
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	183·7	577·61	8000	11·46	·955	
14	$1\frac{3}{4}$	$2\frac{3}{4}$	14·96	$\frac{7}{8}$	145·95	401·07	6000	7·957	·568	11·86
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	148·8	467·91	7000	9·283	·663	
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	170·1	534·75	8000	10·61	·758	
16	$1\frac{3}{4}$	$2\frac{3}{4}$	16	1	129·26	406·25	6500	8·06	·503	13·55
	$1\frac{3}{4}$	$2\frac{3}{4}$		1	149·1	468·75	7500	9·3	·581	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	169	531·25	8500	10·54	·658	
18	$1\frac{3}{4}$	$2\frac{3}{4}$	16·96	1	121·8	383·25	6500	7·604	·422	15·25
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	140·7	442·21	7500	8·77	·487	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	159·4	501·18	8500	9·944	·552	
20	$1\frac{5}{8}$	$2\frac{5}{8}$	17·38	1	124·5	391·49	7000	7·765	·388	16·94
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	142·35	447·42	8000	8·877	·443	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	160·15	503·35	9000	9·985	·499	
22	$1\frac{5}{8}$	$2\frac{5}{8}$	18·76	1	118·72	373·13	7000	7·403	·336	18·63
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	135·6	426·43	8000	8·46	·384	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	152·64	479·74	9000	9·518	·432	
24	$1\frac{5}{8}$	$2\frac{5}{8}$	19·59	1	113·69	357·32	7000	7·09	·295	20·33
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	129·92	408·37	8000	8·102	·337	
	$1\frac{5}{8}$	$2\frac{5}{8}$		1	146·16	459·41	9000	9·115	·379	

Query paper to be filled in when ordering new Twiners.

No. of twiners? No. of spindles in each? Distance of spindles?
Revolutions of main shaft per minute?
Diameter of drums on do.
Diameter of fast and loose pulleys on counter-shaft?
Diameter of drum on do.?
Length of counter-shaft? feet inches.
Driven from above or underneath headstock?
Length of draw or stretch? inches.
Length of spindles? Diameter of wharve?
Length of spindle to stand out of bolster? Speed of spindles?
Twist per inch.

[*Continued on p.* 578.

Weft (*Turns* = $\sqrt{Counts}$ × 3·5).

5	1⅛″ or 1¼″ Ring when using Wood Bobbins = 2¼″ gauge.	7·826	⅞	232·49	638·89	5000	12·67	2·53	4·23
			1	278·9	766·67	6000	15·2	3·04	
7		9·257	⅞	216·2	594·14	5500	11·788	1·68	5·92
			1	235·86	648·15	6000	12·86	1·837	
			1⅛	255·5	702·17	6500	13·931	1·99	
10		11·06	⅞	189·18	519·89	5750	10·31	1·03	8·47
			1	213·86	587·7	6500	11·66	1·16	
			1⅛	238·52	655·5	7250	13·0	1·3	
12	1″ Ring when using Paper Tubes = 2″ gauge.	12·12	⅞	173	474·42	5750	9·41	·78	10·16
			1	202·6	556·93	6750	11·05	·92	
			1	203·52	639·43	7750	12·68	1·05	
14		13·09	⅞	159·84	439·26	5750	8·715	·622	11·86
			1	164·13	515·66	6750	10·23	·73	
			1	188·45	592·05	7750	11·74	·838	
16		14	1	136·36	428·57	6000	8·503	·53	13·55
			1	159·15	500	7000	9·92	·62	
			1	181·88	571·42	8000	11·337	·708	
18		14·84	1	128·69	404·31	6000	8·022	·445	15·25
			1	150·14	471·7	7000	9·359	·519	
			1	171·59	539·08	8000	10·69	·593	
20		15·65	1	132·25	415·33	6500	8·24	·412	16·94
			1	152·54	479·23	7500	9·508	·475	
			1	172·88	543·13	8500	10·776	·538	
22		16·41	1	126·08	396·1	6500	7·859	·357	18·63
			1	145·46	457	7500	9·067	·412	
			1	164·87	517·97	8500	10·27	·466	
24		17·14	1	120·7	379·22	6500	7·524	·313	20·33
			1	139·28	437·57	7500	8·681	·361	
			1	157·84	495·9	8500	9·839	·409	

Zinc or brass guides?
Covering-in boards over tin rollers to be hinged or in one piece?
Width of list boards? Are plummet weights required?
Nos. to be doubled? For what counts is the twiner to be started?
Creels? Length of skewer?
With or without water trough?
Price per spindle? Terms of payment?
If driving apparatus extra?
If water troughs extra?
If patent tightening apparatus for rope taking-in extra?
If brass guides instead of zinc extra?
If to be fixed on stone floor?
Plate bolster? Wood or steel carriages?
Hardcastle's patent continuous creel?
When must the machines be delivered, and how?
Remarks:—
Date Signed by

Cotton Spinning Plant.

To produce 51,244 lb. of yarn, 20's counts, per 56½ hours. (Fig. 136.)

Total Weight of Yarn, etc. required per 56½ hours.		Weights of Slivers, etc.	Calculated Production per 56½ hours.		Speeds D. = Doffers F.R. = F'tRol'rs S. = Spindles	Calculated Total Machinery required.
AT	lb.	HANK	lb.		Revs. per Min.	
Scutcher	55,204	14-oz. scutcher lap	14,000	Per scutcher	1,150	4 finishing scutchers
Carding engine	53,858	·125 card sliver	900	,, card	D. 14·5	60 carding engines
Drawing frame	53,325	·125 drawing ,,	900	,, { finishing / delivery	F.R. 275	60 { drawing frame / finishing deliveries
Slubbing frame	52,797	·6 slubbing ,,	106·6	,, spindle	S. 650	495 slubbing spindles
Intermediate frame	52,274	1·2 intermediate ,,	46	,, ,,	S. 750	1,136 intermediate ,,
Roving frame	51,757	3· roving ,,	17·3	,, ,,	S. 1,150	2,991 roving ,,
Ring spinning frame	51,244	20's ring spinning	2·55	,, ,,	S. 8,500	20,096 spinning ,,

Specification of Machinery on Plan.

1 bale breaker with mixing lattices.
2 porcupine feeds with hopper feed attached and dust trunks. 2 combined openers and scutchers.
8 scutchers (4 intermediate and 4 finisher).
63 carding engines, 37 inches on wire, for 37½ laps.
9 drawing frames (each) with 3 heads of 7 per head (= 63 F.D.).
5 slubbing frames of 106 spindles (each), 17¼-in. gauge, 10-in. lift, 5⅞-in. diameter of full bobbin.
8 intermediate frames of 140 spindles (each), 19½-in. gauge, 10-in. lift, 5-in. diameter full bobbin.
17 roving frames of 180 spindles (each), 20½-in. gauge, 7-in. lift, 3⅜-in. diameter full bobbin.
32 ring spinning frames of 328 spindles (each), 2¾-in. gauge, 1⅜-in. ring, 6-in. lift, for twist.
24 ring spinning frames of 400 spindles (each), 2¼-in. gauge, 1¼-in. ring, 5-in. lift, for weft.

This mill was designed to couple up to, and supply an existing weaving shed, by Messrs. Brooks & Doxey.

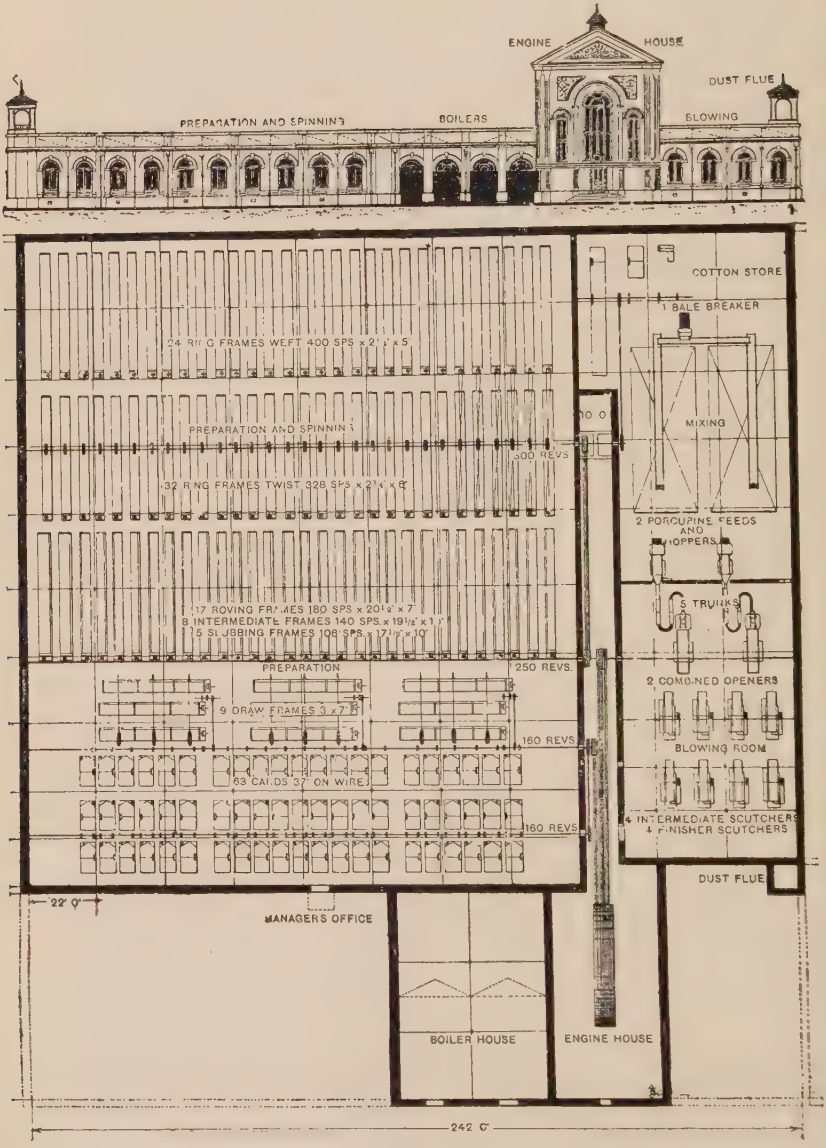

ENGINE HOUSE
DUST FLUE
PREPARATION AND SPINNING
BOILERS
BLOWING
COTTON STORE
1 BALE BREAKER
MIXING
2 PORCUPINE FEEDS AND HOPPERS
5 TRUNKS
2 COMBINED OPENERS
BLOWING ROOM
4 INTERMEDIATE SCUTCHERS
4 FINISHER SCUTCHERS
DUST FLUE
24 RING FRAMES WEFT 400 SPS x 2½" x 5
PREPARATION AND SPINNING
32 RING FRAMES TWIST 328 SPS x 2¼" x 6
17 ROVING FRAMES 180 SPS x 20½" x 7
8 INTERMEDIATE FRAMES 140 SPS x 19⅛" x 1
15 SLUBBING FRAMES 106 SPS x 17½" x 10
PREPARATION
250 REVS.
9 DRAW FRAMES 3 x 7
160 REVS.
63 CARDS 37" ON WIRE
160 REVS.
22' 0"
MANAGER'S OFFICE
BOILER HOUSE
ENGINE HOUSE
242 0"

FIG. 136.

Ring-Frames (Hetherington).

Query paper to be filled in when ordering machines.

How many frames?
Facing gearing end, must pulley be on right or left hand?
Length overall? (Gearing occupies 2 feet 7 inches)
Width of frame? (Usually 3 feet)
Number of spindles?
Gauge or distance between spindles?
Length of lift?
Inside diameter of ring?
Improved "Phœnix" spindle to run twist or weft way?
Diameter of spindle wharve? For bobbins or paper tubes?
Spindles to have solid bottom or detachable oil cup?
Speed of spindles?
Diameter of tin rollers (usually 10 inches)?
Single or double tin rollers?
Counts to be spun? Class of cotton used?
Hank roving to be used? Single or double?
Direction in which roving comes off creel bobbin?
How many revolutions of spindle to one of front roller? or turns per inch?
Creel one height? Or two heights? (See illustrations.)
Separators or anti-ballooning wire?
Diameters of top rollers: Front Second Third.
Diameters of bottom rollers: Front Second Third.
Draft from front to second Second to third Total.
Shortest distance front to second To open to
Front line bottom rollers case-hardened?
Necks and squares of second and third lines case-hardened?
Or necks and squares only of all three lines case-hardened?
Loose boss front top rollers? Ordinary or self-lubricating?
Front rollers dead weighted?
Second and third lines selfweighted?
Or all three lines weighted by saddles, levers, and weights?
Angle or incline of roller stands?
Total length of skewer?
Length and diameter of roving bobbin?
Rope driving and tightening pulleys for tin rollers?
Speed of line shaft? Height from floor?
Diameter of drum on line shaft?
Diameter of pulley on frame?
Driven from above or below?
Are guide pulleys to be supplied?
If by half-crossed strap give sketch.

Is hank indicator to be supplied?
Are top rollers to be covered?
Are clearers to be covered?
Additional change wheels, etc., supplied free of charge:—
4 draft wheels, 2 twist wheels, and 6 top rollers per frame.
If more required, particulars of same to be given.
EXTRAS:—
Loose boss rollers? Wood plugs or sleeve for paper tubes?
Lubricating arrangement for do.? Creel for double roving?
Case-hardened rollers or necks and squares?
Birkenhead type of creel?
Rope driving and tightening pulleys?
Heth's patent separators? Hank indicators?
Full cop stop motion for weft frames? Guide pulleys?
Detachable oil cup to spindle? Covering rollers and clearers?
Above $5\frac{1}{2}$-inch lift?
Patent metal thread lappets?

Multipliers for Twist or Turns per Inch for Fly-Frames.

(Slubbers, Intermediates, Rovers, and Jacks.)

Indian and Low American Cotton.

Slubbers . .	Square root of hank roving multiplied by			1·3
Intermediates .	,,	,,	,,	1·2
Rovers . .	,,	,,	,,	1·5

American and Low Egyptian Cotton.

Slubbers . .	Square root of hank roving multiplied by			1·0
Intermediates .	,,	,,	,,	1·16
Rovers . .	,,	,,	,,	1·25
Jacks (Egyptian)	,,	,,	,,	0·9

Good Egyptian and Sea Islands Cotton.

Slubbers . .	Square root of hank roving multiplied by			0·7
Intermediates .	,,	,,	,,	0·78
Rovers . .	,,	,,	,,	1·1
Jacks (Egyptian)	,,	,,	,,	0·9
,, (Sea Islands)	,,	,,	,,	0·95

Table for Calculating Lengths of Fillets required to Cover Various Sizes of Cylinders, Doffers, Rollers, Etc.

Width of Engine on Wire.	Breadths of Fillets.									
	½ Inch.	¾ Inch.	1 Inch.	1¼ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	1¾ Inch.	2 Inch.
Ins.										
36	18·849	12·566	9·4248	8·3772	7·5398	7·18	6·2832	5·7998	5·3856	4·7124
37	19·373	12·915	9·6866	8·6099	7·7492	7·38	6·4578	5·9609	5·5352	4·8433
38	19·896	13·264	9·9484	8·8426	7·9587	7·5797	6·6323	6·1221	5·6848	4·9742
39	20·42	13·613	10·2102	9·0753	8·1681	7·7791	6·8068	6·2832	5·8344	5·1051
40	20·944	13·962	10·472	9 308	8·3776	7·9787	6·9814	6·4443	5·984	5·236
41	21·467	14·311	10·7338	9·5407	8·587	8·1781	7·1559	6·6054	6·1336	5·3669
42	21·991	14·66	10·9956	9·7734	8·7964	8·3775	7·3304	6·7665	6·2832	5·4978
43	22·514	15·01	11·2574	10·0061	9·0059	8·577	7·505	6·927	6·4328	5·6287
44	23·038	15·359	11·5192	10·2388	9·2153	8·7765	7·6795	7·0887	6·5824	5·7596
45	23·562	15·708	11·781	10·4715	9·4248	8·9759	7·854	7·2498	6·732	5·8905
46	24·085	16·057	12·0428	10·7042	9·6342	9·1754	8·0286	7·4109	6·8816	6·0214
47	24·619	16·406	12·3046	10·9369	9·8436	9·3749	8·2031	7·5721	7·0312	6·1523
48	25·132	16·755	12·5664	11·1696	10·053	9·5743	8·3776	7·7332	7·1808	6·2832
49	25·656	17·104	12·8282	11·4023	10·262	9·7738	8·5522	7·8943	7·3304	6·4141
50	26·18	17·453	13·09	11·635	10·472	9·9733	8·7267	8·0553	7·48	6·545
51	26·703	17·802	13·3518	11·8677	10·681	10·1727	8·9012	8·2164	7·6296	6·6759

Rule.—Find on the first column of table width of engine, and on top line breadth of fillet with which the cylinders, etc., are to be covered. The figures under the breadth of fillet, and in the same column opposite width of engine, give the constant required; multiply diameter of cylinder, etc., by constant, and the result gives length of fillet necessary, in feet.

Example: Doffer, 38 inches on wire × 24 inches diameter to be covered with 1½ inch fillet—Constant, 6·6323 × 24 = 159·175; say 159 feet, the length required.

New Mules.

Query paper to be filled in when ordering new self-acting mules.

How many mules? To stand in what length?
Number of spindles in each mule? For twist or weft?
Speed of spindles per minute?
Gauge of spindles inch.
Length of spindle out of bolster? inch. Length of spindle? inch.
Diameter of wharve on spindle? inch.
Spindle blade any particular sort? If tinned at
If to a pattern spindle? Is the floor tiled or boarded?
Description of headstock—Ordinary? or with rim at side
Counts to be spun? No. of hank roving?
Diameter of tin roller? (Usually 6 inches for twist or 5 inches for weft.)

Is the front line of bottom rollers to be case-hardened?	Diameters of the Fluted Rollers.		Or are the necks only to be hardened?	Diameters of Top Rollers.	
	Front	inch		Front	inch
	Second	,,		Second	,,
	Third	,,		Third	,,

If top rollers for front line to be E. Leigh's patent loose boss?
extra per spindle, at
Top rollers for three or two threads to a boss?
or one thread to a boss? at extra per spindle?
Draft, front to back? Draft, middle to back?
Distance between front and middle rollers? inch.
,, ,, middle and back rollers? inch.
Top rollers to be weighted by lever or dead weights?
If lever weights, fixed or movable?
Weight on top rollers? to be lb.
If dead weights, state weight of each? lb.
Diameter of top clearers? inch.
Top clearers to work over or between the saddles?
Curtain scavengers for carriages?
Or wood roller scavengers for
Wood or steel carriages?
Carriages? at per spindle.
Shaft for soft ends, under the fluted rollers?
Shaft for hard ends, at front of roller beam? at per spindle.
Under clearers with springs or weights?
Iron rods and tin traverse guides? or steel traverse guides?
Wood creel? or iron creel for roving? at per spindle.
Upright or gallery?
For two, three, or four heights of bobbins.
Indicators? at each.
Full cop stop motion (for weft mules)? at per mule.
Size of creel bobbins?
Boarding bottom of carriage? at per spindle.
Plate footsteps? at per spindle
Length of stretch? inches.
Gain of carriage inches
If driven direct or by a counter shaft?
Speed of line shaft? revolutions per minute.

Diameter of drum on line shaft? inches.
Is the driving shaft parallel with the carriage or headstock?
Direct driving from line shaft? at per mule.
Bottom driving apparatus through the floor? at per mule.
Top driving apparatus? at per mule.
Patent regulator? at per mule.
Stretching motion? at per mule.
Roller motion whilst winding? at per mule.
Back shaft and scrolls?
Squaring band pulleys and tightening apparatus? at per mule.
Patent nosing motion? at per mule.
Zinc drippers? at per mule.
Roller motion whilst twisting? at per mule.
Assistant taking-in scroll and ratchet drum? at per mule.

NOTE.—The spare pinions, etc., supplied without charge with each self-acting mule, are as follows: 2 twist pinions, 4 draft pinions, 2 builder pinions, and 6 top rollers.

Is a complete set of change wheels wanted for each mule, or how many?
Change wheels wanted:—

Pinions, Nos. of teeth to
Twist, Nos. of teeth to
Builder to

Are any spare articles to be sent in addition to the above?
When must the mules be delivered and how?
REMARKS:—
Date

Cleaning and Oiling.

An eminent firm gave the following instructions for cleaning and oiling:—

Too much importance cannot be attached to a regular system of cleaning and oiling the various machines, and spinners, carders, overlookers, fitters, and all those most interested, should insist upon a methodical routine being adopted, the result of which will amply repay them, by the more efficient working of the machinery. With this object in view the following has been prepared as a basis to work from in establishing a thorough system.

Lattices, Hopper Bale Opener, and Hopper Feeder.—All principal bearings to be oiled twice a day, and minor bearings once a day.

Openers and Scutchers. — All principal bearings to be oiled twice a day and minor bearings once a day. The under door must be let down about every two hours to clean the dirt from the grate bars. It must on no account be let down when the machine is running. Take all droppings away once a day.

Large cylinder pedestal of "Buckley" opener should be cleaned out about once a week and refilled with very good oil.

Each machine should be thoroughly cleaned once a week.

Carding Engines.—All principal bearings to be oiled twice a day, minor bearings once a day. Card fly and droppings to be taken away every day. The comb boxes should be filled with oil to within $\frac{1}{4}$ of an inch off the top of oil pipe when the card is stopped.

Drawing Frames.—All principal bearings to be oiled twice a day, minor bearings once a day. Electric top roller pivots must in no case be oiled. Fluted rollers to be taken out and scoured, necks and stands picked and cleaned every six months. Gearing to be greased or oiled occasionally.

Slubbing, Intermediate, and Roving Frames. — All principal bearings to be oiled twice a day, minor bearings once a day. Spindle footsteps to be oiled once a month. Collars twice a day. Lifting chains should be oiled occasionally. Grease or oil the principal gearings from time to time. Necks and bearings on electric rollers to be oiled every day. These are apt to be neglected in consequence of being in the creel. Fluted rollers to be taken out and scoured, necks and stands to be picked and cleaned every six months.

Ring-Frames.—All principal bearings to be oiled twice a day, minor bearings once a day. Rollers to be taken out and scoured, necks and stands picked and cleaned every six months. Spindles to be oiled from the top of inner tube every six weeks. Grease or oil gearing from time to time.

Ring Doubling Frames.—All principal bearings to be oiled twice a day, and minor bearings once a day.

Spindles should be oiled at least every six weeks, from the top of inner tube.

Self-acting Mules.—All principal bearing and spindles to be oiled morning and mid-day, spindle tops twice a day, spindle bottoms and minor bearings once a day.

Cap bars and top rollers to be lifted and cleaned every three or four weeks, and more frequently when spinning below 40's counts.

When the mule is stopped for any length of time, care should be taken to oil the loose pulleys.

Winding, Beaming and Sizing Machines.—All principal bearings to be oiled twice a day, and minor bearings once a day.

Rim Shaft Speeds.

The questions of counts of yarn, quality of cotton, twist per inch, and spindle speed, would be primary considerations in fixing the most suitable rim shaft speed. For many years it has been considered better practice to obtain a good speed of line shaft, counter shaft, and rim shaft in order to obtain a sufficiently high spindle speed, rather than to depend upon the use of a large diameter of rim pulley. It is good practice to keep the diameter of rim pulley somewhere near that of the fast and loose pulleys of the rim shaft. If the rim pulley is too large in diameter it puts a greater strain upon the shaft, and it is more difficult to bring the pulley to a stand ready for reversing and backing-off. If, on the other hand, the rim pulley becomes too small in diameter there is a tendency for the rim band to slip. Often also there is considerable loss of time in backing off since a small rim pulley reduces the backing-off speed of spindles with ordinary headstock arrangements.

Rim shaft speeds rule highest for all the medium counts of yarn such as 30's to 50's, speaking in a general way. If, for example, we were going to the extreme of very low weft counts, such as 8's to 14's, the twist per inch would be so small that only a limited speed of rim shaft and spindle would be permissible.

Taking again the opposite extreme of 200's from Sea Islands cotton, the quality of the cotton might require only a moderately sized twist multiplier, while the delicacy and quality of the yarn would render it inadvisable to use a very high spindle speed, unless it were just for the double speed period—and these factors would limit the speed of rim shaft.

850 to 950 r.p.m. are considered good high speeds for 30's to 80's. In waste condenser spinning the r.p.m. of rim shaft may get down very low indeed.

Arrangement of Machinery.

Remarks.—Full length standard mules may be about 127 to 130 feet requiring internal width of mill to be about 134 feet to allow for two passages.

The standard mule spindle gauges for American cotton are $1\frac{3}{8}$ inch for twist and $1\frac{1}{8}$ inch for weft. Fine twist take $1\frac{1}{4}$ to $1\frac{5}{16}$ inch.

The broken gauges of $1\frac{1}{16}$ inch for weft or $1\frac{3}{8}$ inch for bastards are occasionally used.

When cops are spun too near the spindle points they are apt to give snarly yarn due to the latter twisting or drawing-off the spindle points.

A certain English ring-spinning mill contains 60,000 spindles, designed to spin 30's to 66's yarn from American or Egyptian cotton, the latter either carded or combed.

Being a ring mill the yarn may be either

1. Reeled and bundled—long or short bundles.

2. Transferred to flanged bobbins on the slow traverse upright spindle winding frame, and then made into beam warps.

3. Made into cheeses or cones on the quick traverse winding frame.

The mill was started with machinery as stated below :—

4 hopper bale-breakers. 4 hopper feeders, each attached to an opener. 6 single scutchers. 150 flat cards. 3 each of sliver and ribbon lap machines. 24 combers for the finer and better Egyptian yarns. 10 draw-frame of 3 heads each. 10 slubbing frames. 20 intermediate frames. 60 jack frames. 144 ring-frames.

Mill for 32*'s Twist* 45*'s Weft.*

Almost 80,000 *Mule Spindles. American Cotton.*

Summary of Machinery :—

1 or 2 hopper bale-breakers and mixing lattices as required.
3 cylinder opener and lap machines combined.
10 single scutchers.
84 revolving flat carding engines.
11 draw-frames of 3 heads each, and each 7 deliveries.
9 slubbing frames each 98 spindles and 8-inch space.
16 intermediate frames each 132 spindles and $6\frac{1}{2}$-inch space.
40 roving frames each 172 spindles and 5-inch space.
Weft mules of 1,284 spindles each, $1\frac{1}{8}$-inch gauge.
Twist mules of 1,060 spindles each, $1\frac{3}{8}$-inch gauge.

CHAPTER XIII.

ROLLER COVERING.

Rollers and Roller Covering.

Every bit of cotton yarn that is made must be twisted by the aid of spindles, and all of it except that produced in condenser spinning, must pass through draft rollers.

It is fundamental that top covered draft rollers must receive regular attention in various ways, and the leathers kept in good order.

Nothing has yet been found for effectively superseding leather in drafting rollers although many methods and devices have been attempted.

For years the present writer tested composition rollers, made by Bolton people having great hopes of success and spending much money and time on the work.

Searches of patent records made by the writer, added to extensive personal experience and observation, reveal the fact that many inventions have been patented in connection with drawing rollers. Composite materials of many kinds, supposed to be trued up in a lathe, compressed cork, rubber compositions, and mixtures; but an effective substitute for leather has yet to be found, in spite of the fact that good roller leather and the operations of roller covering, are much more expensive than pre-war.

Back and middle top rollers of mules and ring-frames working without coverings, and metallic rollers for draw-frames, offer good examples of not using leather for draft rollers.

Top rollers at any stage in the mill, need constant attention in regard to picking, cleaning, oiling, setting, weighing, driving; and last but not least, in regard to the leather coverings.

Covered top rollers are now sometimes taken out and re-skimmed up but mostly they are renewed with new leathers.

Cloth and Leather.

Leather-covered top rollers are used in every machine in a spinning mill from drawing frame onwards, including the sliver

lap machine, ribbon lap machine, comber, draw-frame, all fly-frames, mules, and rings. The cotton is brought into contact with the rollers in machine after machine, and roller drafting is one of the most used principles in cotton spinning. If the rollers are very badly covered it would be almost as well to stop the machines in ordinary circumstances because the drafting will be done irregularly, and there will be frequent breakages of the cotton with extra work and bad yarn as concomitants.

Roller cloth and roller leather are the two essential materials in covering the top rollers, with a little paste, cement, and varnish to aid in the application of these materials to the rollers. In this country, it is common to use a good wool cloth usually varying in weight from 16 to 22 oz. per yard of 27 inches width. Roller cloth forms a foundation to the leather, gives increased resilience to the leather, and lengthens the life thereof, while preserving the requisite cushion effect on the delicate cotton fibre when nipped between top and bottom rollers.

If anything, the question of roller leather is even more important than that of the cloth. The expense of applying and renewing the leather is so considerable that frequent composition substitutes have been tried at different times, but no other material has yet received much adoption in this respect. Sheep-skins are in very general use as roller leather in our cotton mills, although calf and lamb skin are used to some extent.

Fluting and channelling of the leathers are common results of faulty materials or faulty covering, and either evil will give bad spinning and faulty yarn. Piecings rubbing up, and slack leathers are also in evidence at times. Flutes are longitudinal grooves in the leathers, while channels are peripheral nicks. Uneven drawing, tight threads mixed with slack ones, broken threads, and bad ends accompany when the cloth and leather are of poor quality or are carelessly and unskilfully applied to the rollers. In a recent case of roller leathers very frequently becoming slack, it was proved to be due to a damp and variable atmosphere at nights.

Defects in Roller Coverings.

It might be said that the chief defects are fluting, channelling, roughening, piecings giving way.

As is well known, flutes are hollow places made lengthways in the leathers, while channels are hollow places made circumferentially. Poor leather or inefficient covering will result in any of the above defects being developed. Neglect of cleaning and oiling on the operative's part, or inferior oil, would do the same. Channels are mostly caused by something being wrong with the roving traverse or tin guides placed behind the rollers, although hard

piecings in the rovings, or the latter being hard twisted or rollers set too close, might cause the same evil. The piecings might give way through the use of poor cement or glue, or from want of a good press, or being put on too tight. The leather for rovings for 100's may be the best quality of so-called Persian leather, this being very commonly employed, being smooth, thin, and pliable, although firm.

For rovings for 24's we should have a cheaper quality of skin, which may not have had the same amount of care or labour bestowed upon its preparation. Welsh brown skins are often employed for such numbers. Sheep-skins are generally used, although at times, especially for hard twisted yarn, other material has been tried.

It is well known that the leather should be made to have a cushion effect by a specially manufactured flannel being first applied to the roller.

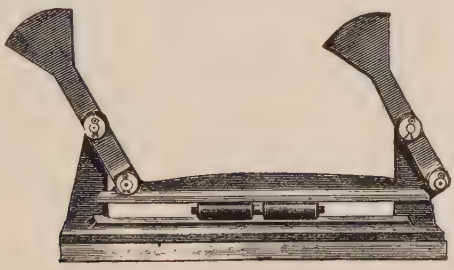


Fig. 137.

Sometimes for fine counts on the mule the flannel cushion is dispensed with.

Uneven work is produced on any of the machines by channelled and fluted leather top rollers, because the channels and flutes detrimentally affect the circumference of the rollers and their biting and drawing power. On all the machines the cotton tends to stick to the fluted leathers, thus excessively breaking the rovings and threads, and leading to roller laps. Particles of cotton and dirt adhere to and accumulate on the rollers, and then pass forward with the cotton.

When the flutes of the iron rollers are badly worn they cannot grip the leathers of the top rollers nor the cotton fibres with sufficient certainty and power, and this leads to irregular drawing of the cotton, giving slack and tight rovings and threads, with inferior spinning and yarn. Sometimes a steel rule laid on the rollers will show inequalities, or recourse may be had to the apparatus shown in Fig. 137.

Short Description of one Method of Roller Covering.

1. The first thing is to get the flannel cushion for the leather cemented upon the bare iron. The operation of cutting up the flannel into long "strips" and into "squares" is often performed by hand, but machines are available by which this cloth is cut up, pasted, and measured ready for application to the roller. The flannels are put end to end, with a "jump" piecing, while bevelled edges are made for the leathers, and are overlaid in piecing.

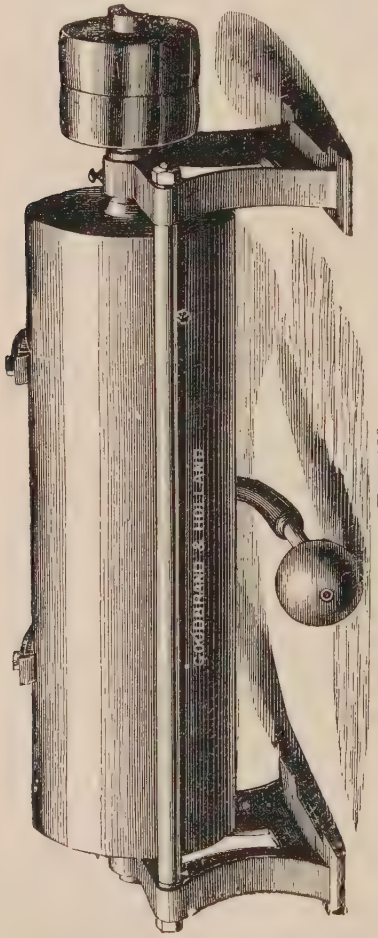


FIG. 138.

2. By the aid of a suitable knife and a "cutting up" board the leather skins are cut up into long strips and then into "squares."

3. The "squares" are shaped into "cots," and the cemented piecings rendered more secure by the aid of a press.

4. A splicing machine is sometimes used before the previous process, and renders great aid in cutting the bevelled edges on the leather "squares."

5. The leathers are drawn upon the bosses of the rollers by the aid of a "pulling-on" machine. Many of these machines stand vertically, and others horizontally.

6. The next operation is "ending" the leathers, by rapidly rotating the rollers in an "ending machine," and burning off the portions of leather projecting over the ends of the iron bosses of the rollers. Fig. 138 shows one make of ending engine, and another make is shown later in this chapter.

7. It is often the practice to place the leather-covered rollers

into a calendering machine, in which the rollers are rolled under pressure, over heated surface plates, so as to put a good finish on them.

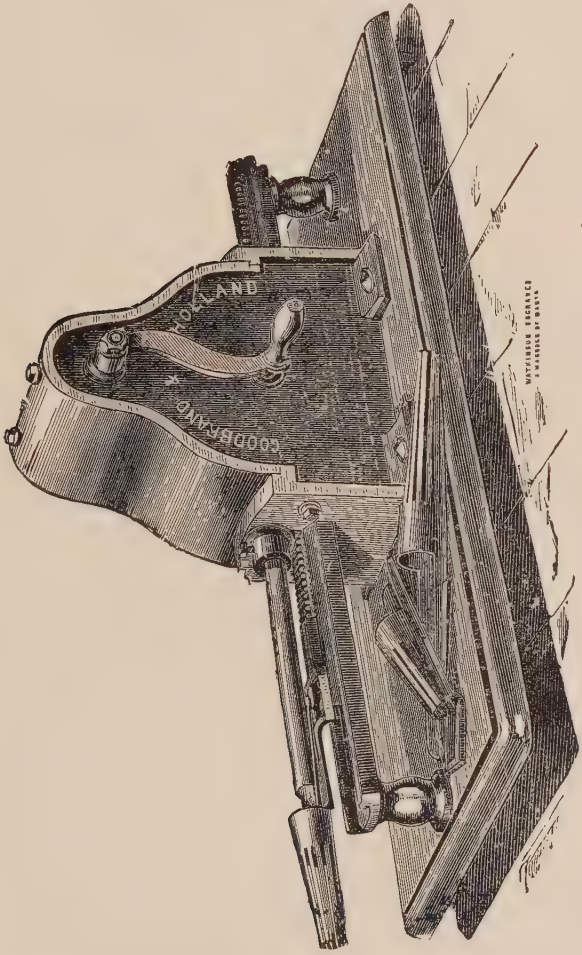


FIG. 139.—One make of "pulling-on" machine is shown here.

Complete List of Roller Covering Machines and Appliances.

Messrs. Dronsfield give the following complete list which may be used, but many spinning firms manage with fewer appliances:—

Pasting, measuring, and cutting machine for cloth.

Choice of { Improved cutting-up board.
,, ,, ,, with slide carriage.
Grinding machine for roller leathers.
Splicing machine, with measuring arrangement.
Choice of { Screw press, with turntable.
,, ,, without turntable.
Lever press.
Choice of { Improved pulling-on machine, single purchase.
,, horizontal pulling-on machine, double purchase.
Power pulling-on machine.
Choice of { Roller ending machine, with fan, No. 1 design.
,, ,, ,, without fan.
,, ,, ,, with fan, No. 2 design.
Roller calender.
Grinding lathe, for truing and varnishing rollers.
Improved varnishing machine.
,, roller tester.

With the above machines will be found necessary the following tools and utensils :—

Stripping appliance for removing old leathers, 1 pair 8-inch combined compasses and callipers, 1 cranked knife, 1 pair scissors, 1 paste knife, 1 stripping knife, two-foot rule, oil stone, rough stone, 2 glue kettles, No. 000 and No. 1, glue brush, 1-5-inch chisel.

Roller Leather.

Occasionally pig-skin may be used as roller leather for rough or very hard twisted yarn. Calf-skin has also been sometimes used.

Lamb-skins are preferably used for the small rollers of fine-spinning mules.

The standard and infinitely the most used material is sheep-skin, Welsh sheep-skins being much favoured in England at any rate. During the war skins prepared in the East met with much acceptance in India and some were imported into England.

Satisfactory roller leather should stand crumpling and crushing up in the hand, and yet return to practically its previous condition.

Good skins are expected to feel soft, pliable, springy, and be free from cracks. They should not be hard, harsh and unyielding, and the glazed surface should be free from hair if freedom from lap-licking and broken threads is required.

Natural variations in thickness of skin are to be expected, but not to an unreasonable extent, and one quick test for this point is to pile up three or four score and note if the pile is reasonably level.

The thickest and strongest portion of a sheep-skin is down the middle from neck to tail, but some note is taken of this in preparing the skins.

The colour of roller skins when reaching the spinner has usually been obtained by manufacturing processes and finishing, and except as an identification mark, is not a guide to natural quality.

The so-called Persian skin is really a trade term.

It is only natural that sheep-skins should vary in size, thickness, uniformity, and other qualities, and since there is an equivalent and corresponding variation in cotton yarns we obtain a rough guide to skin selection somewhat as below.

Method I.—Size of Roller.

The largest and thickest skins may go for the largest rollers such as the rollers of draw-frames, ribbon machines, Derby doublers, and slubbers.

Roving frames, mules, and ring-frames may use smaller and thinner skins.

Skins of medium size and thickness for midway machines such as intermediate frames or roving-frames on lower numbers.

Method II.—Counts and Kind of Yarn.

Allocating roller skins more on the lines of counts and quality of yarn it is natural to choose the finest, smallest, and highest quality of skin to the finest counts of roving and yarn, while lower counts and lower qualities of yarn may manage very well with cheaper sorts of roller leather.

When large skins are also very thin it is likely the thinness has been obtained by grinding or a species of shaving.

Getting Ready for Covering.—Inspection of old rollers before removing the leathers often affords a foreman or manager an indication of whether the roller traverse motion is acting to the best advantage in regard to extent of traverse, whether the whole of the traverse is too much on one side of the leathers, or whether some guide tins are set differently than others.

Great cost of roller skins has led in some cases to leathers being re-skimmed and varnished instead of being renewed.

Often the leathers are removed by the supposedly sharp knife of spinner or piecer, and not infrequently the cloth is thereby needlessly injured. A special four-bladed knife appliance is available for cutting off old leathers.

When cloths are to be renewed as well as leathers, the rollers may be steeped in hot water and soda until both cloth and paste

will easily clean off thoroughly. All roller covering appliances and materials should be kept thoroughly clean.

Roller Cloth.—In England it is customary to use a good, closely-woven, well milled, wool cloth from about 12 oz. per yard in weight up to twice that weight or more, more usual limits being 16 or 17 to 21 oz. A standard width of 27 inches is much adopted. In most cases, but not quite all, it has been found very beneficial to fasten the roller leather upon a cloth foundation previously cemented to the iron roller.

The cloth increases the cushion effect of the leather by means of which the leather bites the delicate cotton fibres very firmly, yet with a minimum of injury to the fibres, while the leather itself lasts longer and becomes less liable to fluting and channelling. If care and skill are exercised in cutting old leathers from the rollers one cloth foundation may serve for several leathers. Speaking from the actual experience of having helped to cut off thousands of these leathers in the mill the present writer would like to emphasise the need of care in this respect.

Union cloth of inferior quality has often been used—especially during the war and for low or medium counts and classes of yarn, or in other countries—but the cushion effect is never the same in results although much cheaper in first cost.

Such cloth may need renewal every time the leather is renewed, and there have been advocates for this system, in spite of the want of "spring" and "cushion" in the cloth.

Application of Cloth to Roller.

Cloth is secured to the iron roller by paste or cement which may be made somewhat as follows :—

(*a*) Steep about 1½ lb. of good fine flour in 3½ gills of cold water for a full day and night.

(*b*) Grind up 1 lb. of amber resin into a small powder and boil this for 25 minutes in 3½ gills of water having the water boiling when resin is put in.

(*c*) Take ½ gill of boiled oil and 2 oz. of Venice turpentine and add these to the resin mixture and boil 5 or 6 minutes longer.

(*d*) Add 3½ gills of boiling water to the flour mixture, stir up well, mix all the above materials together, boil for 30 minutes, taking care to stir well.

Take care to remove any small or large lumps.

Glue, white-lead, paste, and other materials have been more or less used, but paste as above made is the best.

Quick-drying, thin, even spreading, and tenacious fastening are essential features. White-lead is slow drying.

Cloth should be accurately cut into strips and *not torn*. Tear-

ing of cloth introduces danger of uneven edges or ends on the rollers.

Unless the cloth is mechanically cut, it should be cut with a sharp knife, using a cutting-board to get accurate edges.

Avoid having paste left over, but if some is left, it is best kept in an air-tight vessel covered with a damp cloth.

Pasting, Measuring, and Cutting Machine (Dronsfield).

A machine specially designed to prepare roller cloth for accurate and ready application to the rollers, performing simultaneously the operations of pasting, measuring, and cutting the cloth into suitable lengths and widths. Uniform spreading of paste, accurate cutting and measuring, saving of time and labour are specific advantages.

The roll of cloth being suitably sustained in the framing, the end of the cloth is passed through the paste box at the back and over a feed roller covered with card fillet which draws the cloth through the paste box, a handle being used for the purpose. A measuring plate is fitted to slide on a table over a fixed scale and is set to measure exact required length of cloth. Following this pasting and measuring, a knife is pressed down by a suitable handle so as to cut the cloth at a slant, which permits a slight overlap and a better working joint on the roller. Means are provided for regulating the thickness of paste, and there is also a press-plate held with springs and used for pressing the paste well into the cloth.

A smaller machine than the above is available for spreading the paste only. The machine being set to required thickness of paste, the operator draws any desired length of cloth by hand through this apparatus, the paste being done quicker and possibly better than pasting by hand with a knife.

Cutting-up Boards (see Fig. 145, page 603).

Specially constructed cutting-up boards are used in the cutting up of roller skins into strips so as to obtain accurate and rapid performance of the work.

Details of construction and design vary somewhat for cutting-up boards, but identical principles and objects are present. On the board there may be adjustable stops, by the side of which are figured measuring plates.

A planed bar or straight edge is fixed in the centre of the board, and by the edge of a slot which reaches across the board for the knife to enter. This planed bar is raised and lowered at both ends equally by means of a handle.

The roller skins are passed beneath the raised bar up to the measuring stops, and then the bar is dropped to hold the cloth firmly while the cutting knife is drawn across the board, against the straight edge, the knife point running in the slot.

A rather more elaborate board contains a double straight edge arrangement, one on each side of long slot.

The double bar forms a slide on which is fitted a knife carriage, with the knife able to cut both ways.

The double bar and sliding carriage give greater solidity of pressure, so that the board is not only suitable for roller skins, but also for such softer materials as clearer and roller cloths and plush.

Roller Leather Grinding Machine.

This may be used for grinding the flesh side or under side of skins intended for roller covering in order to reduce them to uniformity in thickness.

Really uniform skins are highly desirable for roller covering but are not obtainable naturally, and there are variations in thickness, strength, and quality even in the same skin.

Prior to grinding in this machine the skins are cut into strips of required width to avoid waste. Each strip is submitted to only that amount of grinding this narrow width requires.

Each strip is placed on a carrier drum, one end passed through a slot and fastened by clamp, the other end of strip hanging loose. A suitable handle is operated to move the leather strip towards the grinding roller, the leather passing beneath a stretching bar before reaching the grinding roller.

The carrier drum is adjustable to the grinding roller in order to regulate the depth of "cut," a fan being used to draw away the ground-off material.

The grinding roller is covered with glass filleting.

Splicing Machine.

This term is applied to an apparatus used for cutting leather strips with bevelled edges—each strip exactly equal to the circumference of roller to be covered, the bevelled edges being designed to form the joints or piercings of the "hots" or sleeve for the rollers.

The leathers are placed on a suitable table, face side down and passed under feed rollers. A specially devised mechanism enables exact and controlled lengths of leather strip to be passed forward. There is a suitable stop and scale measuring device.

The leather in passing through the rollers falls under pressing

bars, the pressers are brought together, and the knife brought into position.

The knife is drawn across the slide by a hand-worked operation which gives a clean bevel cut and equal angle of cut, so as to aid in obtaining a really good joint.

In this case the cutting knife is square, having four edges, any one of which may be readily set for use. Special knife sharpening facilities are provided.

Presses and Piecings.

The pieces of leather are now ready for application so far as preliminary treatment and cutting are concerned.

The bevelled edges help in making good piecings on the "hots," "tubes," or "sleeves" of leather. Special cement is used for the piecings, and some kind of pressure is applied to the piecings.

One rather old method consists in using an iron bar resting on a wood frame and termed in some districts the "piecing horse."

The operater rolls a two-handled roller over the piecing while the "tube" is on the bar.

Good cement is essential and a favourite mixing consists of about equal parts of acetic acid and gelatine or isinglass, used very sparingly so that it will not cause any small hard places on the leathers or rollers.

Apart from the above mentioned rolling method for establishing the piecings there are specially designed presses of both the lever and screw type all operated by hand.

In the lever press the top pressure bar may be raised or lowered by means of a lever and eccentric.

In the simple screw press the cemented tubes are immediately placed beneath the presser bar.

A somewhat more elaborate screw press contains four separate arms for the leather "hots," carried on a turn-table. One arm is always facing the

Calendering Machine (Fig. 140). (Dronsfield).

To set the machine, first lift up the top rolling plate A, and insert a roller on the front edge of the surface plate; then turn the arm wheel until the bowls are just out of contact with the rails FF, say $\frac{1}{32}$ of an inch.

Before commencing to use the machine, put the two plates in contact, so that both may be heated; after use, again put the plates in contact to preserve the surfaces from the penetration of dust and damp.

The top of the steam chest is planed and polished perfectly

true, to form the surface plate; over this is fixed a rolling plate A, mounted on bowls to run on the rails FF, and worked to and fro by the cranks N.

The rollers are placed on the receiving table B, and each roller in turn is fed automatically on to the surface plate, rolled four times backward and forward, then deposited on to the delivery table C, another roller being immediately fed in by the feed motion to take

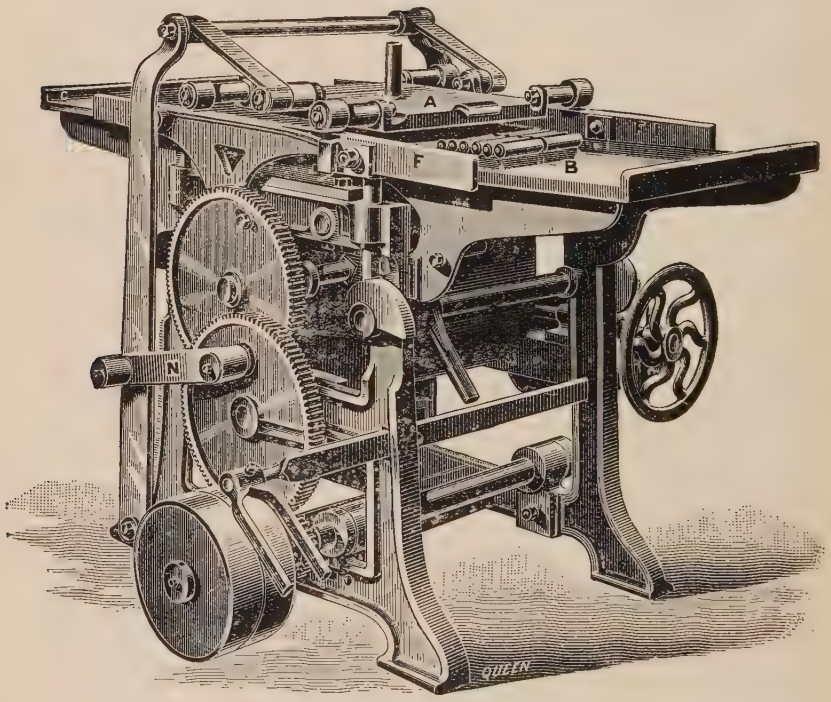


Fig. 140.

its place. Thus after the machine is set to calender rollers of the required diameter, it may be left to do its work, all the actions being automatic.

Varnishing Machine (Fig. 141).

High prices of leather and re-covering generally have helped to favour the idea of re-grinding leather-covered rollers after working some time, and many spinning firms now possess special lathes

for re-grinding and varnishing. About 1885 the author worked close (at John Wood, Bros., Glossop) to a spinner who was much troubled with roller laps owing to one mule being next to the mill wall, lined with windows exposed to very detrimental north-east winds. Frequent roller varnishing was necessary at times and this spinner rigged up a small framework to hold each roller, rotated by thick string from a convenient shaft. The machine shown at Fig. 141 contains the same fundamental principles fully carried out on sound mechanical principles and is specially arranged for varnishing as distinct from grinding.

Frequently it will be found necessary to varnish the rollers only, without grinding them, as, for instance, in the case of mule rollers employed in the spinning of fine counts. The varnishing machine Fig. 141 is specially made for this work, and is a simple and neat contrivance by means of which the rollers are quickly varnished whilst revolving, permitting the varnish to be well ingrained in an even layer on the leather surface. The machine takes in all sizes of rollers, and the latter can be inserted and removed in an instant with the aid of the spring chucks which carry them. Various kinds of chucks to suit the different kinds of roller ends are sent with the

Fig. 141.

machine. Loose boss rollers may be quickly varnished by placing several on a spindle, the ends of which should be threaded and fitted with lock nuts ; this spindle is then placed in the chucks like an ordinary roller. Spindles of this character to suit the particular class of roller may be easily made at the mill.

Roller Ending Machine (Fig. 142).

The ending tool is most frequently of boxwood, but leather, bone, and other materials are used at the discretion of the coverer.

The type of machine now most frequently demanded is the Roller Ending Machine (Fig. 142). This is here shown with a fan, but may be had with or without fan as desired. The fan is a useful adjunct, serving not only to remove the fumes and dirt caused from the burning of the leather by frictional contact, but also as a ventilator for the room.

The machine consists of a polished cylinder A, balanced for high speed, to be run at 700-1000 r.p.m. At the back of the cylinder is fitted a slide carrying arms BB, in which are held brass steps for the rollers to revolve in. When worn thin the thin part

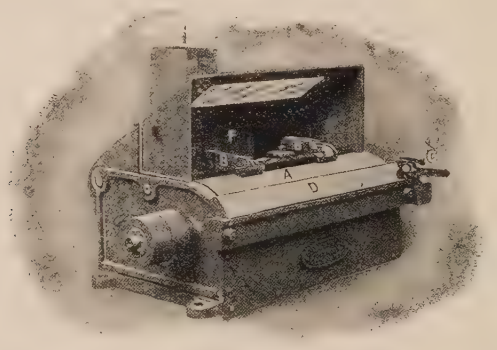


Fig. 142.

of the step may be cut away and the step moved up, in this way permitting same to be used again and again until too short to fix in the brackets. The steps are raised and lowered by the lever C, the weight putting pressure upon the roller to cause frictional con-

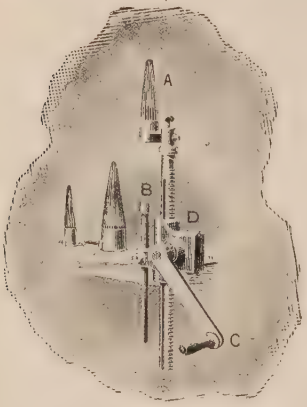


Fig. 143.

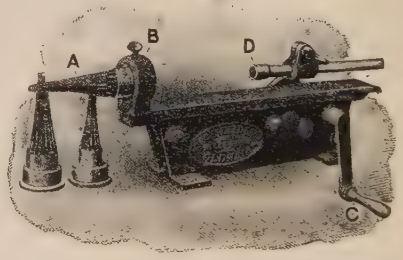


Fig. 144.

tact with the cylinder. The fan is fitted in the centre behind the machine, and is driven from the cylinder shaft. The fan mouth E is movable so as to facilitate the fixing of the ventilating pipe in any desired position.

Pulling-on Machines.—Dronsfield's vertical pulling-on machine s shown at Fig. 143, and has a single purchase rack and pinion.

At Fig. 144 their horizontal machine with triple purchase as recommended for large rollers such as ribbon lap machines and draw-frame rollers.

Uniformity is essential in the pulling-on machine, free from jerking of handle, and the machine should be strong enough to do the work forcefully and gradually without jerking.

Roller Tester.—This apparatus is shown at Fig. 137, and is for the purpose of testing or gauging the bosses of rollers to ascertain whether they are covered truly or otherwise. It consists of two parallel surfaces, the upper one being suspended to rise and fall to any diameter of rollers. By the use of this tester any irregularity in the covering of the rollers can be readily detected.

Roller testing may apply: (1) to the bare cast-iron, (2) after covering, (3) after grinding. (See page 591.)

Cutting-up Board (Fig. 145).

Cutting-up boards differ a little in detail but not much in principle.

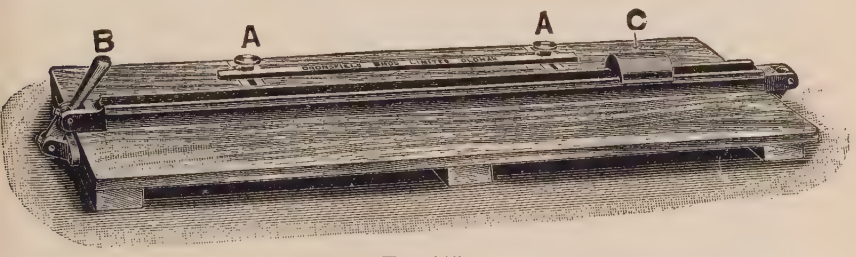


Fig. 145.

The one shown is fitted with adjustable measuring stops AA The planed straight edges are made to rise and fall, both ends together by the handle B, and are fitted close to a slot in the board for the knife to enter. Several skins may be cut up at the same time if desired.

When skins have been cut up into strips they may be arranged in grades of thickness for the different kinds of rollers. Each strip of leather may be trued up by grinding away only just sufficient leather to obtain equality in thickness, a feature which is essential for best results. A slide carriage may form part of the cutting-up board.

In making the leather splicing it has been stated that for sheepskins a 12 degree cutting angle is best and for calf skins 15 degrees. These angles give a bevel of medium width, wide enough to get an excellent joint unlikely to break open.

Drawing-on of "Hots."

The present writer's first observations and experiences of roller covering (about 1876) were concerned with lathe-like machines in which cutting, measuring, application, and cementing were all done with the roller held in the machine. The leathers were not made into "hots" or tubes and there was no drawing-on machine.

For many years now the general custom has been to make "hots" or tubes of leather suitable for size of roller used, and then to use a "drawing-on" or "pulling-on" machine to get these "hots" on the roller boss.

While slack "tubes" are inadmissible, yet undue stretching of the tubes of leather is an evil to be avoided.

The tube springs should not be over-long owing to difficulty of drawing springs away after applying the leather. Springs too short may cause undue friction between cloth and leather.

Overlapping of springs, wires becoming twisted, springs not lying evenly on rollers, are evils to be unavoided, and the springs should cover about three-quarters of the roller.

Formerly a system was used in which foot levers were used for drawing-on by the aid of ropes.

Details of modern "pulling-on" machines vary somewhat; there being in one case a single purchase rack and pinion moved by handle, the machine being vertical.

In a second example the machine is horizontally disposed and has a triple purchase, making a powerful hand machine.

Yet a third example represents a power pulling-on machine in which a train of steel-cut wheels is used, driven by a band, through which a chain is operated and takes the place of the ordinary rack.

By the use of a "pulling-on" machine the leather is drawn upon the roller gradually, the tube being forced open in a mild manner so that neither the piecing nor the leather is damaged.

The vertical hand machine is very popular for all rollers of moderate length and diameter. The horizontal hand machine is deemed preferable for large rollers such as those for draw-frames and ribbon machines.

The semi-power machine is useful for such rollers as combers and drawings.

In the operation of a hand machine, the roller is held on the stud, the tube is mounted on the spring and is then drawn over the roller by turning the handle. When the "hot" is pulled sufficiently on the roller, the operator grasps the outer end of the "hot," and continues to turn the handle until the spring wires are withdrawn from between the leather and the cloth.

Cutting-up.

This should be performed with care and precision.

Suitable skins having been selected they are first cut up into strips $\frac{3}{8}$ or $\frac{1}{2}$ inch wider than the roller, the extra being for ending.

The natural direction of fibre-growth is from head to tail, and skins should be cut in this direction and not across their width. The centre of the skin may be used for large rollers such as draw-frame, strips on either side for fly-frames, and outsides or edge strips for the final spinning machines.

The Hair Side for Working.

When used, the grinding machine grinds the skin or furry side leaving the outside or hair side unground, this being the best draughting medium, only to be removed by any subsequent grinding or varnishing.

Ending of the Roller Coverings (see Fig. 142).

As stated it is customary to leave short overhanging portions of leather at the roller ends, each tube or "hot" being slightly longer than its roller or boss.

Snipping off by scissors or knife is not the best method, and for a long time the custom has been to burn off these leather ends by frictional contact, the roller being revolved very rapidly while the ending material is held against its end. In mills having both spinning and weaving slashers thrums have sometimes been used for ending. Heated irons have been used. Ending tools of leather, bone, boxwood or equivalent material have all been used, by far the favourite being the boxwood. It is best to apply the boxwood tool to the edge of the leather and work outwards and downwards in order to get a good end effect. Any defect will affect the spinning, the collection of dirt, and licking up of fibre.

The central and chief feature of an ending machine consists of a well-polished metal cylinder making possibly 850 r.p.m. more or less. Suitable bearings are provided to sustain each roller as it rests on the cylinder and is revolved by frictional contact therewith at a very high speed, while the boxwood tool is held against the leather ends to burn them away. In this way an excellent and well made up end is obtained, which holds both leather and cloth firmly in place and quite prevents oil, dirt, or fly from getting inside the roller. The bearings for the leather rollers in the machine may be readily altered or renewed. The process creates somewhat unpleasant fumes, but the best machines are fitted with hood and fan to quickly take fumes or burnt material away.

Machines without hood and fan may be simpler and cheaper but are faulty in direction indicated.

Some machines are fitted with apparatus which holds the roller away from the cylinder when changing rollers.

Calendering (see Fig. 140, page 600).

Although not absolutely essential, machines are in extensive use for calendering the rollers after covering, the operation consisting of rolling the rollers between heated surface plates. A leather-covered roller is never at rest when under treatment in this machine.

Piecings may leave a slight tendency towards hard or flat places on the rollers, there may be slight variations in cutting the leathers, or in pulling the " hots " on the rollers, and the ending process may tend to slight blistering.

Calendering is designed to remove any such inaccuracies and is a kind of finishing process by machine, irrespective of the question of varnishing.

It is designed to remove slight imperfections but will not make bad rollers into good ones, nor is it a remedy for unskilful and careless covering or bad leather.

Steam heating being so very general in a spinning mill, this machine has usually been fitted with a steam-chest for heating, but arrangements may be made for heating either by steam, gas or oil, and possibly also by electricity if local circumstances are in favour.

The steam chest possesses inlet and outlet taps and a tap for drawing off hot water or condensed steam.

The top of steam chest is well polished and accurately planed to form the lower calendering surface.

The upper planed plate is arranged to roll about on bowls, with several rollers between. About four times backwards and forwards is considered sufficient treatment.

The operation is automatic when the required adjustments are made. The upper plate is allowed to rest on the lower one for heating up before using and placing the rollers between.

Varnish Recipes.

1. (*a*) Take 5 ounces of common glue and dissolve in 1 quart of cold water for twenty-four hours.

(*b*) Take 4 ounces of gum arabic and dissolve in $\frac{1}{2}$ pint of cold water for twenty-four hours.

(*c*) Take 4 ounces of chromate of lead or yellow chrome, also 4 ounces of sub-chromate of lead, and also 3 ounces of green paint, and finally 2 ounces of black lead ore or powder. These four last

articles being all in powder are ground well together in water to the consistency of soft putty.

(*d*) The dissolved glue and gum are put together and made into 2 quarts and placed in a pan on the gas fire. When sufficiently hot the other or powder mixture may be added along with 2 tablespoonfuls of wood naphtha. This gives a varnish in the form of a jelly when cold, and when wanted a sufficient amount will be heated, made thin enough, and applied with a camel-hair brush.

2. (*a*) 1 lb. best pulverised fish glue or the equivalent in gelatine.

(*b*) 3 pints acetic acid, or else 1 quart acetic acid plus 1 quart of water, or else 2 quarts of good vinegar.

(*c*) $\frac{1}{2}$ lb. of Venetian red.

(*d*) $\frac{3}{4}$ ounce of oil of cloves or oil of origanum.

The glue should be broken up as finely as possible and put in a jar with the acetic acid and allowed to stand for twenty-four hours, with occasional stirring. Then add the other ingredients and stir well.

The war caused a great scarcity of some varnish materials and also gave very inferior qualities which spoiled the effect in the mill.

3. 2 lb. of chrome yellow.

$\frac{1}{2}$ lb. each of lamp black and rouge.

$1\frac{1}{4}$ lb. of joiner's glue.

The glue may be boiled in 4 quarts of water; the other three ingredients should be thoroughly well pounded and powdered together; all ingredients to be now mixed together, and simmered for half an hour with ample stirring. If necessary dilute with warm water. Before using this varnish may need a little warming.

Grinding of Covered Rollers.—Varnishing.

Reference has previously been made to the grinding of long strips of leather *before* covering, this grinding occurring on the flesh side. A second grinding is more or less in vogue *after* the rollers are covered and must therefore be done on the hair or working side.

The detaching rollers of combers are longer than any others, are necessarily of small diameter, are weighted at the ends, and their work requires to be done very exactly in order to effectively detach the cotton without curling it. About 12 inches length on leather × $\frac{7}{8}$-inch diameter, with 20 lb. weight at either end of a Heilmann roller and less on a Nasmith.

For these reasons many fine spinners required newly covered detaching rollers to be externally ground, and the operation to be repeated at intervals. Varnishing always follows this skimming, and a soft, velvety, rather thick varnish improves the detaching action.

The benefits of this grinding have been apparent when skilfully

done by the aid of a suitable machine, and the system has spread to other kinds of leather-covered top rollers, high prices of new leather helping in this direction.

Such skimming up often takes the form of doing little more than skimming off all the old varnish before applying fresh.

Special, lathe-like machines are available for this grinding and subsequent varnishing, and it is recommended to apply the varnish thinly, by means of a suitable soft brush or cloth while the roller is being rotated. Trueing up or re-skimming may be more needed for long rollers such as draw-frame, ribbon machine, sliver lap machine and slubber rollers, but mule and ring-frame rollers are sometimes advantageously treated, especially if hollow places are very shallow.

The machine available for the purpose is quite simple to work. The roller is fixed in spring chucks which run in ball bearings, one chuck being adjustable for different lengths of roller. Exact settings are more important for grinding than for varnishing.

The length of traverse agrees with the length of roller to be ground and is fixed by certain stops mounted on a top reversing bar. As the grinding wheel comes alternately into contact with these stops the direction of traverse is reversed. Glass-coated fellet is recommended for grinding, and can readily be renewed by the operator. Means are provided for fine and accurate adjustment of grinding wheels, for collecting the dust and for applying a fan if desired.

After the grinding of rollers, the reversing and grinding motion straps may be removed while the rollers are varnished.

A more simple machine is available for varnishing rollers only. It consists of a framing to hold roller chucks which are adjustable for holding any length of roller, and pulleys for quickly revolving the rollers during varnishing.

Several loose boss rollers may be varnished together by first threading them together on a spindle which is itself suitably sustained in the chucks and suitably revolved.

The long-established method of varnishing rollers at the machines themselves, without using any special appliance. is still in use at many mills.

CHAPTER XIV.

INTERNAL CONDITIONS OF SPINNING MILLS.

Lighting of Spinning Mills.

General Principles.—The problem of lighting resolves itself into the two primary divisions of natural and artificial lighting. With regard to the natural light, the great size of the rooms of a spinning mill, combined with the fine nature of much of the work involved, has led to the maximum amount of wall space being devoted to the windows, these being as wide and high as possible. A good height of room and well-whitened ceiling facilitate the distribution of the light. The natural lighting problem has been intensified in regard to the card-room by the desire to place all of the card-room machinery on the ground floor of the mill, but the difficulty is practically overcome in most modern mills by building a shed extension to the card-room with roof lighting. Gas and electricity have been for many years past strong rivals for favour in regard to spinning mills. New mills often find it convenient and best to at once lay down plant for producing their own electric lighting. In older mills a very large number of firms have adopted gas mantles in order to give a better light with reduced gas consumption, and the use of these mantles has been improved by the adoption of intensified gas mantle lighting, in which the illuminating power is increased by putting the gas under a specially obtained pressure. In every case natural light should reach the frames from the end or ceiling, and artificial lights should be placed in the alleys. Blow-rooms and cards have usually fewer lights than later processes. Peel Mill, Turton St., Bolton, built forty years ago, is a good example of maximum window space, and has always been known as the "Glass Factory."

The Ring-Rooms.

Probably the most convenient method of setting out a ring spinning room for natural lighting—as well as for other conveniences—is to have two rows of ring-frames running down the length of a room from 85 to 95 feet wide, the end of each ring-frame coming up to alley-way under one of the lines of windows. In

this way the light can pass without interception across the width of the room either in front or behind the frames. It is advisable to have the windows reaching almost up to the ceiling, and as wide as may be convenient, as this helps the uniform diffusion of the light. If the ceilings are kept white and clean so much the better for the spread and effect of the lighting. There are now various kinds of thick glass in use, which prevent seeing through, but which help to collect and diffuse the light in an exceedingly effective manner so long as the glass is kept clean.

The Two Methods.

Referring to the two great rival methods of artificially lighting either ring or mule spinning rooms, viz. by gas and by electricity, there are sub-divisions or special features appertaining to each which require consideration. The electricity may be either generated on the premises or obtained from the town or a company, and may be either of the ordinary incandescent lamp type, or some special form of lamp, such as the half-watt, or a limited number of enclosed powerful arc lights may be used. Ordinary plain, exposed gas burners may be used, or ordinary long gas mantles, or inverted gas mantles, or gas mantle arrangements in which an intensified light is produced.

On the whole it is perhaps the best plan to equip a mill with electric lamps, and generate the electricity on the premises, as this is such an exceedingly neat, convenient, effective, and safe method. It is doubtful, however, whether a mill already well equipped with gas lighting would find it profitable to convert to the electric method, especially as the introduction of gas mantle lighting has greatly increased the lighting power of the gas illuminant, while at the same time much reducing the quantity of gas consumed. These two effects are still further increased by the use of the intensified light as obtained by the use of a special burner along with gas at an increased pressure. In some towns it is best to use town current.

Electric Lighting is exceedingly convenient for switching on or off at special localised places, or when dark intervals occur in the daytime. In many cases it is found better to use corporation electric lighting, than to produce it at the firm.

Many types of lamp have received favour at one time or another such as the Tantullam. At the time of writing (1922) the half-watt lamp is much favoured as giving a good light at a moderate cost, although the lamps yet made in England appear easily spoiled. Modern, self-contained electric hand-lamps are very safe and very useful for shining on dark gearing points or using for piloting purposes when the main lighting is off.

In regard to natural light a good north light is desirable, but it

will serve from any side of the mill if the windows are large enough and preferably arranged to shine down the alley-ways rather than behind the creels.

Lighting.

When we compare most cotton spinning and weaving machines made to-day with those made twenty to twenty-five years ago it is astonishing what comparatively slight differences we find, compared with what we find in such things as electrical driving and lighting.

The shape, quality, and c.p. illumination of electric lamps provided twenty to twenty-five years ago would serve very indifferently at the present time compared with the later lamps.

Willing, energetic operators with good eyesight formerly worked with very poor gas lights and before that with candles or lamps. Workers require better illumination nowadays.

With electricity, recent mill lighting examples have been briefly described somewhat as follows :—

(*a*) Generator belt-driven at 500 r.p.m. from a shaft making 175 r.p.m., 200 volts, 40 kw.

Conduit wiring in which all main and lamp circuit wiring is enclosed in screwed conduits, and all conduits are set possibly $\frac{1}{2}$ inch or so away from ceilings and walls. Conduit runs continuous from the main switchboard, through distribution boards, to each lighting point, the pendant falling from a conduit rose of porcelain, mounted, with a fibre disc, on a malleable iron-screwed box.

Flexibles all of toughened rubber, being durable, strong, and easily cleaned. Recent type of fuse-board suitable up to 25 amperes at 500 volts, the boards filled with fuse units so mounted as to facilitate inspection and wiring. The present writer has seen some fuse boxes and contents in a very bad, burnt, and broken condition after a few years' working and it is well that more attention is being paid to this feature.

The new fuse unit has considerable mechanical strength, ample contact area, contact slips of phosphor bronze, easily re-wired, and well protected.

Sufficient expansion space for explosive gases, and means for such ga es being carried away.

Bus bars of heavy section, section high conductivity metal, each having heavy cable sockets.

Cases water-tight, extra strong, heavy hinges, good clearance all around metal parts.

Fuse units are mounted on a frame suspended from four points, and by removing two accessible screws, the whole interior may be swung open and outwards. Dividing fillet of non-warping, fire-proof material.

Mule-Rooms.

In mule-rooms the custom of placing the artificial lights down the centre of the wheel gate tends to have the operative intercepting light from shining on the rollers when he is piecing-up.

Half-watt lights arranged zig-zag out of the centre of wheel gate, give a better effect on the piecing-up point.

Notes.

Blow-rooms and carding engine areas are not usually deemed to need as much lighting as jack frames and mules, where the work is much finer.

Double windows, so often used in Russia, do not appear necessary in England.

Windows may be about 7 or 8 feet wide × about 10 or 11 feet high in modern mills.

Electric Gas Lighter.

There is such a thing as an *electric hand lamp* and gas lighter. With this a person may pilot himself when the lights are out to the gas jets he wishes to light up. The lighting is effected by pressure on a button or on a projecting rod, thus causing a number of bright sparks which light the gas but cause no fire danger.

As far back as 1890, the author had considerable mill experience of small electric gas lighters which were very efficient, but were often out of order. Improvements have, however, been effected so that each lamp may carry a battery sufficient for at least a winter and seldom be out of order.

Oil lamps constructed on the principle of the Davy safety lamp, with wire gauze protector, have been used in mills to some extent, for gas lighting.

Good v. *Poor Lighting.*—Good lighting is very desirable in textile mills, but has not always been provided. Defects and imperfections in the cotton or in the machine, detection and piecing up of broken threads or bad ends, receive quicker and more efficient attention in a good light, whereas bad lighting leads to inferior work and reduced productions. Accidents to operatives and machines, and discontented workers, are less likely to occur when satisfactory—not wasteful—lighting is provided. When in the mill, however, the author often found the workers too careless at putting out the lights when no longer needed.

Gearing of change wheels, adjustment of mechanical parts and detection of faulty action of same, easier supervision of processes and machines, and accurate reading of orders, are items of benefit resulting from good lighting.

Lighting may be faulty in respect of retaining old-fashioned methods, in having lights too weak or too few, in being out of order, in being placed in wrong positions, in throwing shadows, or in obstructions to light.

Lights are often gauged by the c.p. or foot candle. An electric lamp, for example, may be stated at 32 c.p. or 100 c.p. (candle power).

Intense illumination may be needed for fine work on dark materials, while blow-rooms may do with a very reasonable amount of lighting.

Excessive brilliancy—such as occasionally provided with strong unshaded arc lights—may cause eye fatigue, but insufficient lighting causes eye strain.

Well whitened, clean walls and ceilings, help greatly in the diffusion and efficiency of lighting.

When diffusing globes and reflectors are used they need to be kept well cleaned.

The severity of the artificial lighting problem in cotton mills, has been eased by the 48 hours' law which has mills starting at 7·45 a.m. instead of 6 a.m.

Tungsten filament lamps give a sufficiently white light for most mill purposes.

From the point of view of cost of production, the provision of good lighting works out to a very small amount per pound of yarn produced compared with some other items such as wages.

Heating of Spinning Mills.

Efficient heating of cotton spinning mills is highly necessary for the good working of the material and machinery, quite as much as for the comfort of the workpeople.

The natural conditions found to be necessary for growing cotton are also best for its cleaning, opening, and spinning into yarn.

Spinning-rooms especially need to be well heated, say 70° to 95° F., the higher ranges of temperature being found usually in mills spinning the finer counts of yarn.

About 75° F. is considered suitable for many rooms in which 20's to 50's counts of yarn are spun from American cotton, whereas 85° to 95° F. is a more usual range for mills spinning 100's to 200's.

The light wearing apparel adopted by mule spinners when working often consists only of cotton shirt and cotton drawers, with bare feet; sometimes an under-shirt as well. Sometimes thin shoes are worn, or slippers.

Steam boilers and steam engines have been used for driving cotton spinning mills for over 100 years, thus providing a con-

venient medium for supplying the high degree of heating needed. With the development of higher boiler pressures steam pipes were changed from about 4 inches inside diameter of cast-iron pipes, to wrought-iron pipes of $1\frac{1}{4}$ to $1\frac{1}{2}$-inch diameter and steam pressures 60 to 90 lb. per sq. inch, this type maintaining in favour for very many years, although some still prefer lower pressures and larger pipe diameters. This is known as the direct system of heating. Essentials for efficient heating service may be as stated below.

Sufficient progressive fall from feed to delivery, freedom from awkward meeting points of steam in the pipe lines, freedom from back pressure at any point, satisfactory *reducing valves* at the steam inlet if very high boiler pressures are used, efficient steam traps at exit points, valves at correct positions in the different rooms of the service so that the steam may be shut off, or allowed in any part as required ; pipes suspended about 8 feet from the floor so as not to be in the way of carrying bobbin or cop skips or too near the heads of the operatives.

The very dry nature of the cotton in any stage, the nature of the operations, possible interference with the work of machines or operatives, combine to make the floor an undesirable position for the steam-pipes, although this position might give greater heating power in the working parts of the rooms, and is occasionally used.

There are *ventilating humidifiers* in which the incoming fresh air may be heated as well as moistened, but this method of heating mill rooms is not very suitable for spinning mill rooms ; nor is any system of hot-air heating.

This hot-air method may be termed the indirect or blower system of heating.

Another system is the hot water or forced circulation method which has been found suitable for many public buildings, but neither quick enough nor powerful enough for cotton spinning mills. The hot water method, however, requires little attention, has a low fuel consumption, and operates on the well-known household method of automatic cold water replenishment when hot water is drawn off and natural rise of hot water to higher levels. The adoption of electric driving and electric lighting may favour the hot water method for mills in the future.

Mill Heating.—In 1836 Dr. Ure wrote as follows :—

"The first cotton mill upon the fire-proof plan was erected, I believe, by Messrs. Strutt at Belpher, in 1797, others in 1801, 1802, and 1805, since which time all good factories have been built fire-proof.

"The heating of the apartments of the cotton factories is effected by a due distribution of cast-iron pipes of about 7 or 8 inches diameter, which are usually suspended a little below the ceilings.

traverse the rooms in their whole length, and are filled with steam from boilers exterior to the building.

"It has been ascertained that 1 cubic foot of boiler will heat fully more than 2,000 cubic feet of space in a cotton mill, and maintain it at about 75° F.

". . . It has also been ascertained that, in a well-built cotton factory, 1 superficial foot of exterior surface of cast-iron steam piping will warm 200 cubic feet of air.

"The pipes must be freely slung, and left at liberty to expand and contract under the changes of temperature, having one end at least connected with a flexible pipe of copper or wrought iron of swan-neck shape. Through this pipe the water of condensation is allowed to run off. The pipes should not be laid in a horizontal direction, but have a sufficient slope to discharge the water.

"The pipes are cast from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch in the metal. . . . In practice the expansion of steam pipes of cast-iron may be taken at about $\frac{1}{10}$ inch in a length of 10 feet when heated from a little above the freezing up to the boiling-point of water.

"In arranging the steam pipes provision ought to be made not only for the discharge of the water of condensation, but also for the ready escape of air; otherwise the steam will not enter freely.

"Even after the pipes are filled with steam, a little of it should be allowed to escape at some extreme orifice, to prevent the re-accumulation of air discharged from the water of the steam-boiler. In consequence of the water left in steam pipes serious accidents may happen, for when the next time steam is admitted into them, the regularity of expansion and heating is impeded, some part of the pipe may crack, or a violent explosion may take place, and the joints may be rocked to a very considerable distance, every way, from the place of rupture, by the alternate expansions and contractions. The pipes should therefore be laid, so as to have the least possible declivity, in the direction of the motion of the steam."

For a plant consisting of many buildings somewhat scattered, some of them well away from the boilers, the hot water system may do nicely, but these conditions seldom apply to cotton-spinning mills, referring now to present day mills.

Boiler Steam.—The general custom is to use live or boiler steam direct from boiler to steam pipes, with reducing valves, steam remaining in pipes until condensed and final discharge either into the atmosphere or into a tank for the boiler feed again.

Distinct benefit often results from returning the condensation from steam pipes to boilers again, using special traps, and this system is much adopted.

Various detailed devices have been more or less used instead of feeding steam direct from boiler to steam pipe. For example, low

pressure steam has been taken from the receiver of a compound engine and fed to the mill steam pipes.

Even in the U.S.A. greater variations in temperature are experienced than in Lancashire.

The increased window space of modern mills and very high rooms, naturally require a greater amount of heating in winter time.

Some spinning mill rooms work with three lines of 1½ inch piping stretching transversely over the creels of the mules 120 feet long. Other mills have four lines and some have tried with one line near each mule end. The quantity of air which may be heated by 1 lb. of steam, condensed into water, and discharged at any temperature can be calculated by formula. Inside diameters of pipes are referred to.

Thick walls, double windows, and small windows, help greatly to maintain heat in spinning mills, but in England the first condition only is deemed advisable, while all three are wanted in Russia. The very few cotton spinning mills of one storey in England have found greater difficulty in maintaining heat in winter, than do five or six storey mills in which protection is afforded by one room over another.

The value of high pressure steam as against low pressure for heating purposes, depends primarily upon the additional condensation per hour from each square foot of surface.

Summer Heat.—It has to be noted that often in summer, even mills in the English cotton spinning centres naturally become much too hot in the daytime, when using little or no steam, especially ring-rooms.

It is quite evident also that in hot countries, such as India and South America, it often becomes a question of cooling rather than heating the spinning-rooms, and humidifiers may be more use than steam pipes; this is not true of England.

Natural Heating.—Apart from the steam pipes put in for heating, special positions are often affected by such circumstances as the following:—

Proximity to boiler house, frictional heat from the machinery, the influence of the sun shining directly upon certain side windows, as well as entering by the roof in upper storeys or shed buildings, internal lighting.

The bodily heat given off by operatives can only have a small effect in spinning mills because of the large cubic space area per individual; but a weaving shed or winding-room may feel this influence more so.

English managers back from Russia inform the author that double windows in Russian mills serve an excellent purpose, especially if well-made and kept in good order so that the space between

the two windows is practically air-tight; if any of these windows are broken an appreciably worse effect is obtained. Rather small windows compared with English mills.

Electric Heating in Cotton Mills.

Cotton spinning mills require a great deal of heating since cotton spins best in an atmosphere of about 78° to 90° F., the greater heat for the finer counts, and a modern spinning mill is a huge concern requiring in its entirety very many thousand cubic feet of space to be heated.

This is one reason for the continued favour of main driving of spinning mills by steam engine in which the steam required for the engine can so readily be diverted for heating purposes.

Electricity has not made such great progress for heating large buildings as it has for driving large or small installations of machinery. Attention, however, is being given to the problem of electric heating in the textile industry.

The war years, 1914-18, not only revealed terrorism, waste in previously undreamt of degrees, and wholesale destruction, but also revealed creative and inventive features of a truly remarkable nature, at any rate along certain lines

The price of coal, of recent years so very high in this country, has been still more against some countries abroad, and this has had an effect in the direction of electric heating in those places where water power is abundant.

One installation in Switzerland is briefly referred to below:—

"This mill can obtain current at nights from a central electricity works when its own hydro-electric power obtained from the river should at times be diminished. The idea was formulated of obtaining electric heating by means of heat accumulation.

"The steam heating has been discarded. The heating plant has been adapted to electric heating by installing an electrically-heated water system. There is now a hot water accumulator plant together with the necessary pumps.

"A central heating system has been adopted to do away with the need for large heat storage, since the essence is to utilise stored heat.

"The water of a large boiler is first heated by an electric flow-through boiler during the night. In the early morning hours the boiler water attains a heat at which the storage boiler is automatically cut off from the circulating system and its heat is therefore conserved.

"The water in the system then circulates through the electric 'flow-through' boiler and the radiators in the rooms to be heated ready for work commencing, at which time the night current is

automatically switched off, and the hot water stored in the boiler can be circulated. In this way a seven-storey building is heated as well as smaller ones.

"It is stated that heating has been obtained sufficient to meet an outside temperature of 5° C. below zero, and that general results have proved quite satisfactory."

Ventilation and Dust Extraction.

In recent years the two greatest developments in regard to dust extraction and the ventilation of cotton spinning mills have been :—

1. The introduction and extension in use of modern ventilating humidifiers.

2. The compulsory application of dust extractors to carding engines, which must operate every time the card is stripped. These may be intended only to remove the stripping and grinding dust and floating fibre or may be extended in use to have also the duty of actually stripping the cylinder and doffer by an air current instead of using the brush, possibly supplemented by using the stripping brush also, about once per week.

Ordinary fans have often been applied to particular rooms in a cotton-spinning mill, apart from the question of humidifiers or card stripping.

In mule spinning-rooms fans have often been objected to by the operative spinners, on account of the operatives often working in bare feet, wearing only cotton drawers and a cotton shirt, with or without an underneath flannel undervest. They are, however, used in connection with certain makes of humidifier.

Fans have proved more useful in ring spinning-rooms on account of the greater heat generated by the closer proximity of the machines, and the tendency for the women ring-frame tenters to faint. Extraction of more or less vitiated air and inlet of fresh by the use of fans appears more used in ring-rooms than mule-rooms, in Lancashire.

Fans.— Large diameter fan boxes may be often seen from the outside of spinning mills, as fitted in the windows of card-rooms. The author has been in some card-rooms in which double doors were essential on account of the strong air currents caused by using several fans of 28 or 30 inches diameter.

It has long been a fundamental law in applying fans to card-rooms, that the air shall be drawn over the frames to the cards, and not over the cards to the frame, but the introduction of special stripping dust removers to carding engines has perhaps reduced the value of the above procedure.

Some firms employ fans and others employ pumps for removing the floating dust and fibre during stripping.

Gassing-Rooms present problems of special difficulty in regard to ventilation, owing to the dual feature of requiring the air freshening even more than other rooms, while also making it difficult to provide effective ventilation without blowing the lights and seriously affecting the quality of gassing.

Partly for this reason shed buildings have been recommended for gassing-rooms, but this law is by no means always applied, and much higher rooms are more or less in use.

It is recommended that fans in gassing-rooms may be fixed in the roof, and fresh air inlets provided underneath the frame with the idea of the incoming air carrying upward the fumes of the gas and floating impurities due to the singeing.

Factory Acts.—According to the Factory Act reasonable conditions must prevail in regard to ventilation, temperature, and humidity in every factory. In mule spinning-rooms the machines are so large and the operatives so few (for the area) there is no doubt about sufficient cubic feet per person being provided. Nor is there much doubt about this point in other parts of spinning mills.

Whether the air be sufficiently fresh is a rather different matter. The requirements of the cotton fibre for efficient working also compel spinning firms to keep their mill rooms sufficiently warm, and, indeed, some of the rooms become too warm in summer. Humidity requires more attention when ventilating humidifiers are used, which is by no means always the case.

The rooms of cotton spinning and doubling mills require to be (1) warm rather than cool, (2) slightly humid rather than very dry, (3) purified by dust extractors without causing currents of air which may disturb the cotton or detrimentally affect the workpeople.

Even the large air space per operative afforded in blow-rooms, card-rooms, and spinning-rooms is scarcely sufficient unless there is movement and change of air due to open windows and doors, or the use of fans or pumps.

Air flow and chemical composition of the air both require consideration.

Agreement.—By agreement the following temperatures were recommended :—

Card-rooms and ring-rooms . .	60° to 80° F.
Mule-rooms	70° to 95° F.

Employers agreed to provide thermometers in the spinning-rooms.

From the standpoint of chemical composition of the air it has been decided for some kinds of works that the proportion of carbon dioxide shall not much exceed 4 parts in 10,000.

From the point of view of air movement it has been suggested that not less than 3,000 cubic feet per person per hour is desirable, this representing about six changes per hour. In gassing-rooms a much higher standard per hour is required for air movement, and perhaps also in the vicinity of revolving flat carding engines.

Fresh air should enter at a low velocity, not exceeding in some cases about 250 feet per minute, and in winter it is better in spinning mills if the air is warmed either by efficient external steam pipes, or by ventilating humidifiers.

Air inlets should be sufficiently large to prevent draughts. Natural means of admitting air for ventilation have the defect of creating draughts, especially in windy and cold weather.

During recent years mechanical ventilation in spinning mills has become much more common.

Ventilating Systems.—1. What is termed the "plenum" system of ventilation represents one established method.

On this plenum principle fresh air may be *forced* into the rooms by fans, and the foul air forced by the fresh air, out of doors, windows, crevices, or special outlets.

2. What may be termed the "exhaust" system of ventilation works more on the opposite principle from the plenum, and is the system which was established in many card-rooms long before stripping dust extractors were compulsory, and is yet the simplest and most favoured.

In the exhaust system the foul air is extracted by fans, and the fresh air flows in by natural means at doors, windows, crevices, or at special positions.

1. The plenum system forces fresh air into the rooms, and permits foul air to escape by any natural means.

2. The exhaust system, extracts the foul air and permits fresh air to enter naturally.

3. There are mechanical ventilators which aim at combining both the plenum and exhaust principles.

There has been preference given to exhaust ventilation because it is the simplest, cheapest, most direct, easiest to apply and operate.

The best way to apply exhaust ventilation to a card-room is to put the fans in the window framing along the same side of room as the cards.

A gassing-room may be ventilated by fans at the top and air inlets beneath the frames.

Positions of Fans.—A long narrow room is best ventilated crosswise unless there is a special reason to the contrary.

Occasionally fans are placed down both sides of a room and air permitted to enter near the middle.

When fans are placed at the end of a long room it is more

difficult to carry the air the full length of room. Care should be taken that fans placed high up do not draw the air from the roof, ceiling or other high up positions without ventilating the desired room.

Fans.—The flat faced type of fan so very largely used for openers and scutchers is not much fancied for ventilating purposes. Ventilating fans are usually of the propeller type having ability to move large volumes of air at rather moderate speeds, light in driving power required, with air pressure not varying much on the different sides of fan.

Electrically driven fans—as might be expected—have been gaining in adoption in spinning mills, but there are still good points in favour of belt driving, such as (*a*) convenience in mill shafts, (*b*) ability to alter fan speed by means of pulleys, (*c*) starting and stopping of fan with the shafting.

Framework for fans should be well fitted, and care given to the amount of projection of fan inside or outside the room wall.

For best results such fans require free access of air on intake side, free discharge, correct revolutions per minute, and correct diameter and size of blade, ample air supply to the room which is ventilated, protection from outside winds and other interference. It is best if the direction of air extraction is faced away from the prevailing winds, and may be best fitted with wind shields or screens.

As in the case of openers and scutchers, the bends of any trunks or pipes used for ventilation require to be as smooth as possible, free from abrupt bends and sharp corners.

The driving power for fans varies with the cube of the revolutions per minute.

The supply of fresh air should be as clean and pure as possible and sometimes air cleaning cloths or other materials are used, especially in the case of ventilating humidifiers.

The output of a fan may be tested by means of the anemometer, which permits a determination of the average velocity of the air current over the discharge area.

It is possible also to determine the chemical composition or purity of the air by collecting samples in bottles, sealing the same, and subsequent examination.

Flow of Air.—It has been laid down that a standard of six changes of air per hour is advisable, the ventilation being spread as uniformly as possible through the rooms.

It is very important that air draughts be avoided in cotton spinning mills, both from the point of view of disturbing the delicate cotton, and also possible harmful effects on lightly clad, heated operatives.

It has been suggested that air should enter in the rooms at a

low velocity—say not more than 250 feet per minute. The author has been in fan ventilated rooms in which the opening of a door has promptly caused a very strong air-flow. Double doors check or stop this.

The propeller kind of fan is best for ventilation, and should be aided by such conditions as below stated: satisfactory speed, screening from external winds, free intake and discharge of air, adequate supply of fresh air to the card-room or spinning-room when the used air is exhausted.

Fire Prevention and Extinction.

While sprinklers, fire engines, stand pipes and hose pipes play a great part in extinguishing large fires, all experience proves that a valuable part is played by small separate fire extinguishers in the case of smaller and incipient fires. Sprinklers, of course, are useful for either large or small fires, but form part of a general installation rather than complete self-contained units. Except for general connection to a forceful water supply, each sprinkler head is a complete unit.

Chemical fire extinguishers maintain a strong position in spite of sprinklers; some of them may be carried in the arms, others on the back of a person, and still others one in each hand of a person.

It has been said "A little fire is quickly trodden out; which, being suffered, rivers cannot quench."

Stopping a fire at its start is the surest method of preventing disaster, and fires are only small at first.

The cheapest and usually most plentiful liquid for fire extinction is water, which reduces the fire temperature to below ignition point, and puts a fire out on the "cooling down process."

Water is a conductor of electricity, and is in this respect rather dangerous to use in extinguishing fires generated by short circuits, or possibly by friction in motor bearings.

Sand, for example, may extinguish a fire on the "blanketing" system, but is obviously unsuited for a spinning mill, bad for the machine bearings, and difficult to apply to overhead fires.

In some fire extinguishers a special liquid is used (not ordinary soda and acid mixtures) suitable for inflammable substances; and this liquid is a non-conductor, forms a vapour "blanket" on meeting the flame, extinguishing the fire by cutting off the supply of oxygen required for combustion.

Small Fires.—Fires of oil, tar, gas, celluloid, benzine, grease, cotton, cotton yarn, oily bearings, oily wood floors, and mule carriages, are best extinguished by special materials.

Fires of materials that burn freely, such as dry wood, paper or straw will yield readily to water extinguishing.

What is termed the "Pyrene" extinguisher contains an effective liquid, and in its small size of about 14 × 3 inches, weighing 6 lb., has found its way into many cotton mills for use against fires at their very beginning. This appliance is typical of some others. This extinguisher holds about 1 quart of the liquid, may easily be refilled, and will discharge in any direction to more than 20 feet when worked like an ordinary hand pump. The flow is continuous, pumping may stop at will, and liquid left over may be good for future use.

When this liquid comes in contact with fire at 200° F. or over, it forms a heavy, dry, cohering, non-poisonous vapour blanket, which separates the flame from the burning material by cutting off the further air supply. This liquid is stated to be free from acids, alkalis, and salts, being composed of purely organic substances. Fire extinguishers, of course, are not confined to cotton mills in their utility.

Discounts or rebates on insurance office charges, allowed for providing efficient fire prevention and extinction arrangements, have materially helped forward mill equipments in this direction.

Insurance may compensate for actual damage done to buildings, machinery, or stock, but may not compensate for loss of trade and good will.

Fire danger is increased by operatives surreptitiously using matches, by neglecting to keep fire extinction apparatus in good order, by careless storing of oily or other waste, by swinging gas brackets, by neglecting to oil quick-running bearings, by straps biting on loose pulleys when machines are stopped, by electric wires not properly encased, by dirty machinery.

Soda and Acid Extinguishers.

During recent years several makes of portable extinguishers have been much adopted, being usually cylindrical in shape, of weight and size suitable for readily carrying by one man, practically always ready for instant use, fitted with permanent tubing and nozzle, and started either by turning the vessel upside down, or else by only reversing the nozzle from the outside. In early makes of these extinguishers handled by the author about 1890, the bottle had to be broken by a smart external blow, and the over-sudden mixing occasionally caused bursting of cylinders.

Instead of a patent, special liquid, advantage is simply taken to utilise the effervescing and discharging effect of mixing sulphuric acid with bicarbonate of soda liquid.

There are several makers with differences in detail.

In every case when no longer required, the extinguisher may be placed right side up again, and the flow of liquid is stopped.

Cylinder made of lead-coated steel, or polished copper, tested to 400 lb. per sq. inch. Charge quantities of acid and soda may be separately obtained, or mixtures made according to formulas.

The sulphuric acid may be contained in a bottle sustained at the internal upper portion of the large liquid cylinder, which latter is filled with a solution of bicarbonate of soda. The acid bottle in at least one case has a long lead stopper, which, upon the machine being turned upside down, falls downwards and permits the acid to discharge and mix with the soda solution. This generates carbonic acid gas and creates pressure sufficient to force the liquid for several yards out of the cylinder.

After using, such a cylinder should be promptly recharged. One method is by mixing the bicarbonate of soda in a half-bucket of cold water—possibly 2 gallons or so—then filling into cylinder and adding water up to the water line marked.

The lead stopper should replace the ordinary cork in the bottle of sulphuric acid, and the bottle carefully placed in its position in cylinder. The cylinder should first be washed out with clean water. Top of cylinder well screwed down.

Cylinder Fire Extinguishers.

Two types of fire extinguisher in Bolton Technical School are shown in Figs. 146 and 147.

Fig. 146.

Fig. 147.

The "Empire" or "Underwriter" may be easily carried in both arms of an average person to the position of the fire. In this case the appliance may be turned upside down to upset the acid into the soda solution, and thus force the liquid out. In some cases the nozzle only is turned over. This is a very strong extinguisher of a typical character, easily installed in window bottom, or any convenient stand, and tested to 400 lb. per sq. inch. Directions for re-filling are :—

"Fill the tank with water to inside projection. Add 1½ lb. of bicarbonate of soda. Stir well. Fill the bottle half-full of commercial sulphuric acid. Place the 'stopple' in the bottle and place the bottle in the cage. Screw the cover on tight. Protect from freezing."

The small "Pyrene" is of a still smaller kind, pumped by hand, filled with special liquid. When the Pyrene liquid comes into contact with fire an elastic blanket of non-poisonous gas separates the flame from the burning substance. It is claimed to extinguish fires of moderate size whether electric, gas, chemical, oil or petrol, a non-conductor of electricity and a non-corroder.

The "Kyl-fire" represents yet another type of hand fire extinguisher. Kyl-fire is a dry powder contained in cylindrical tubes, the contents of which quickly extinguish fires. Non-acid and non-deteriorating.

Principles of Liquid Fire Extincteurs.

The great merit of the sulphuric acid and bicarbonate of soda mixtures is automatic action without using any pump, but extinction is on the "cooling down" principle.

A distinctive merit of such mixtures as the special small "Pyrene" is fire extinction by the "blanket" principle and super effects of a small quantity of liquid, but applied by the aid of hand pumping. The "sand" buckets, useful in some cases, are little use in cotton mills, but represent another method.

Automatic Fire Pump.

One of the more recent devices in regard to fire-fighting consists in an automatically controlled electrically driven fire pump.

This represents another of the rapidly multiplying applications of electricity and is a distinct advance on the older styles of steam fire pump, at the same time showing a saving in first cost and running cost. For a steam pump to be always ready for action requires attention at nights, week-ends, and holidays, but this is not at all true in an electrical pump.

A recent installation was described somewhat as follows: "The pump comprises a two-stage turbine with a 7-inch diameter

delivery, and is mounted on the same bed-plate as, and direct coupled to, an electric motor, absorbing 63 b.h.p. The pump can deliver 650 gallons a minute against a pressure of 120 lb. per square inch, which is more than a standard corporation fire engine.

An efficient water supply is provided from a convenient source to the pump well, the pump being always primed and ready for action. At the delivery end of the pump hydrant connections are provided, apart from the work of the sprinklers. The automatic control has a hydraulic ram, with its cylinder connected by a 2-inch pipe to the sprinkler main. Over 80 lb. per square inch of water pressure keeps the ram at the top of its stroke.

Assuming a fire to fuse and start one or more sprinklers, the water pressure is reduced in the mains to 80 lb., at which point the pump ram descends, the motor starts, and the pump feeds the sprinklers. Pumping continues until sprinkler delivery ceases or until the pressure reaches 120 lb., at which point the ram remains at the top of its stroke and the pump stops.

Safety Locking for Hoists.

Most people with long experience of cotton spinning mills have unfortunately known of serious accidents with the hoists or lifts, either through failure of some part of the mechanism, or through one of the doors being open at a wrong time.

For more than 100 years cotton spinning mills have been built very high—mostly five or six stories, so that automatic hoists have been advisable for taking bobbins, cops, or other material from one storey to another. Factory inspectors now compel employers to apply safety devices to hoists—especially in regard to the opening and closing of the hoist doors in the various rooms and levels.

Lift accidents, fatal and otherwise, are still liable to occur and in 1919, for example, there were quite a number. There has always been a temptation for young persons to meddle with hoists, and even older persons have not been entirely exempt from such interference.

It has been stated that the majority of hoist accidents are due to the following causes :—

(*a*) Crushing between the tops of doors and the floor of the descending cage.

(*b*) Crushing between the floor of a room and a descending cage.

(*c*) Crushing between the gate and the fencing of the well.

(*d*) Falling through getting in and out of the cage whilst in motion.

(*e*) Catching on projections in the hoist well.

Fundamental recommendations by inspectors are :—

(1) That the door cannot be opened until the cage is at rest opposite the floor of the landing. (2) The cage cannot be moved away until the door of the hoist is closed. (3) When an interlocking gate or door is fitted, it shall not be possible to have accidents such as previously referred to. Having now special regard to the latter requirement when in the cage itself there is an interlocking door or gate.

A recent device referring to this requirement is termed "The Whittles" safety locking gear, for which it is claimed it can be applied to any make of hoist and any kind of door. It is considered an advance on appliances which only lock the starting chain, but does not interlock with the cage and loading doors as it is less dependent on operatives.

There are various arrangements for vertical sliding doors, and others having a pair of hinged doors.

Referring now to the latter the starting chain is provided with a length of flat metal strip, termed the actuating bar, on each landing, and on the cage itself there is an iron cam inclined at its lower and upper ends. Each will operate a pivoted lever carrying at its lower end an anti-friction bowl. The flat portion of the cam moves the lever, and causes it to pivot and draw the bottom bar forward, so that the bracket on the centre of the bar automatically releases the catch holding the centre or pilot bolt.

The bolt is released, and when the cage is stopped the pilot bolt fits in a slot in the flat iron strip previously mentioned on the starting chain, thus fastening the starting chain and telling that the driving belt is on the loose pulley.

By turning the handle in the centre to an upright position the door may be opened, as this releases the top and bottom bolts in the door and brings forward the iron cam running in a horizontal position on the door. Opening of the door means that the anti-friction bowl on the top bar engages with the inclined part of the door cam, forcing the top bar into the wrought iron strip or working bar, at the same time withdrawing the centre pilot bar to ordinary position.

In this way it is secured that when the door is opened the cage cannot be moved away from that level or landing since the top bar is now holding fast the starting chain.

When the time comes to close the doors and move the cage, it is impossible to work the cage until the doors are closed, and the doors cannot be left loose as the top bolt does not disengage from its lock until the door handle is turned into a horizontal position, and this operation puts the top and bottom bar in the door and also moves the door cam to its original position.

The same makers construct an outside control arrangement which is perhaps of greater benefit when no regular hoist attendant

is employed. By this "outside control" the cage can be moved to and from any desired level when no person is in the cage and doors are shut and locked.

The safety arrangement above described may be applied to single or paired hinged doors, to doors which slide vertically, or doors which slide horizontally.

Yarn Conditioning.

It is the established custom to submit spun cotton yarn to some system of moisture conditioning. Apart from any question of weighting the yarn all experience proves that humidity or moisture to a certain extent is natural to cotton, and that it passes better through most of the processes of spinning and weaving mills when at least that natural moisture is retained.

There are many methods of conditioning yarn, of a slow, medium or quick character, but the more thoroughly all the component parts of yarn package is permeated the better, whether the yarn be in reeled hank, mule cop, ring-frame bobbin, wound cheese or cone, or in any other form. Outer layers are naturally permeated first, and inner layers gradually attract a greater or less proportion of the moisture. The density of a yarn package and the system of conditioning both affect the treatment duration.

Equal, thorough, and reasonably quick conditioning are desirable, the celerity being more required when the yarn is fortunately in demand. It is better when layers of cops, tubes, or other packages can have the same conditioning as the outer ones, in the minimum of time.

At an important Bolton mill the present writer recently saw the "Halliwell" yarn conditioner.

Apparently a base idea is to create such a vacuum that a current of air is ensured through every cop, bobbin, cone or cheese.

The central mechanism consists of an airtight chamber from which the air is extracted to form a partial vacuum and then returned to the chamber to destroy such vacuum.

In a rapid circulation the air passes through the skip from the top to the bottom, through all spaces in yarn or package and rapidly changing the air surrounding the fibres.

An atomised spray of water is projected into the circulating air previous to its return to the conditioning chamber; and the yarn under these circumstances rapidly assimilates the moisture.

There may be placed in an enclosed chamber of the Halliwell conditioner a number of skips of yarn—possibly eighteen equally arranged in three trolleys. Witnessing the operation, and comparing mule cops before and after, the writer noted that the manager was

satisfied with the process. It appears easier and less liable to disturb the cops than the much used damp cloth application method to rows of cops.

The three trolleys of yarn inside the chamber have the bases of the skips resting within the upper edge to form some sort of joint and so that the air passes *through* each skip. The skip bottoms and trolley base form a space, and at the back end of each trolley two tubes are provided through which the air is extracted. Different tubes form sealed joints.

A fan is used to create more or less of a vacuum, and above the fan the air enters a small chamber and shortly becomes saturated by meeting an atomised spray of water, obtained by means of a steam injector which both warms and moistens the air, the heating being a help to quick conditioning. The warm humidified air is conducted so as to pass through the packages of yarn previously prepared.

The trolleys run lightly upon slips, and the operatives can do the work of charging and emptying the yarn chambers quickly and easily. The chamber being closed upon the yarn the operative starts the fan and steam, a period of possibly 15 to 25 minutes serving for the entire conditioning. Gauges may be used to note the atmospheric conditions. The installation seen by the writer served for a combination of several large mills and contained several conditioning chambers, and apparently one or two chambers or boxes will serve for one large mill.

Sprinklers and Inspection.

At the time of writing one important firm of sprinkler makers maintain a special department for the inspection of sprinkler equipments, and for a specified monetary consideration will regularly send trained experts to examine and report upon the conditions of any sprinkler installations.

Defects have often been found in sprinklers under such heads as below specified.

(*a*) Defective or improperly maintained water supplies.
(*b*) Main water valves closed.
(*c*) Impaired equipments.
(*d*) Obstruction of sprinkler heads.
(*e*) Alarm and valve defects.
(*f*) Alterations to buildings without corresponding alterations to the sprinkler equipment.

A sprinkler installation may exist for years without coming into active fire operation, and this sometimes leads to somewhat careless examination on the part of the mill staff.

Fire Alarms.

The automatic fire alarm or bell has almost always formed an essential part of sprinkler installations.

If required, however, it is quite feasible to apply an independent fire alarm which may be hung near the ceiling of any room.

A small fire near this alarm may quickly raise the temperature near the ceiling to about 165° F. and fuse a link, thus releasing a powerful spring which operates the gong hammer for four or five minutes.

Possible incidentals to fire extinction comprise such items as the following:—

Goggles, asbestos, gloves of leather or rubber, gas masks, rubber boots, warning and danger signals.

It is possible to render articles practically fire resisting by impregnation with fire-resisting solution, which is suitable for curtains, cushions, cloths of good quality, canvas, flannelette.

Fire Escapes.

Permanent external fire escape staircases show up prominently on the outside of most storey cotton spinning mills.

The lowest storey of these escapes may be hung up out of the way ordinarily.

A door or window opens upon the landing for each storey of the mill. Sometimes the ladder or stairway for the several landings are arranged in zigzag order, and at other times in continuous progressive order along the outside of the mill.

Secured to the mill walls by strong cast-iron brackets and substantial forged bolts, strong enough to ensure safety in case of panic crowding when a fire occurs.

Fire extinguishers may be summarised as follows: Water buckets, hand-fire extinguishers, fire-engines, stand pipes and sprinklers. Materials, pure water, special liquid, special powder, or soda and acid mixture.

One of the readiest and oldest fire-extinguishing appliances used in cotton mills consists of buckets kept filled with water. These are extremely serviceable in cases of small fires, and have been of the utmost utility in numberless instances. One of the worst defects of this system is that the buckets soon become empty, owing to the evaporation of the water and other causes. Periodical refilling of the buckets is therefore necessary, and this is often neglected. Times without number mill officials have got into little difficulties with the insurance people owing to empty buckets. Often spinners are so busy piecing up, doffing, etc., in these days of quick speeds, at the time for refilling that they are almost compelled either to miss refilling the buckets or stop the mules up for

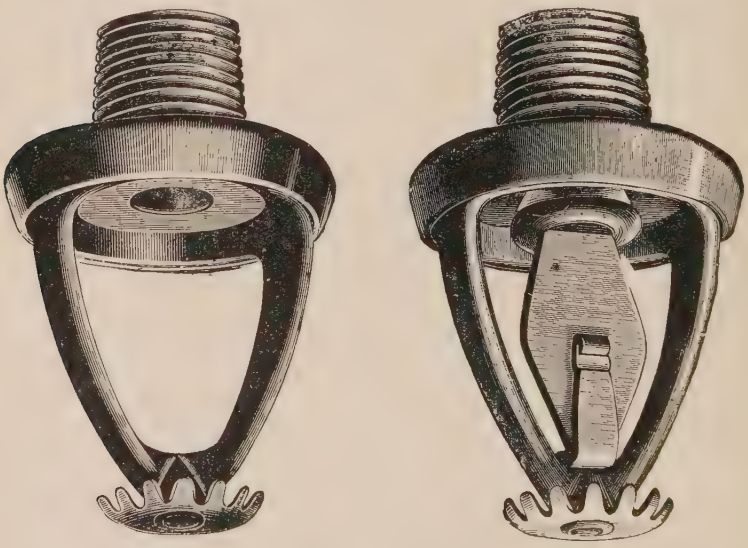
a short time. An American firm got over the difficulty by adopting the somewhat expensive method of hanging each bucket upon a hook fitted with a piece of spring steel in such a manner that when the weight of water in the bucket got below a certain amount a bell was rung in the manager's office, thus directing his attention to the nearly empty bucket. Even with modern fire extinguishing apparatus, in the opinion of the author, the water bucket is worth retaining. It is possible to have buckets with lids on, or even have them filled with special liquids for fire extinction.

Formerly it was a very common plan to have attached to a mill of any size a ponderous fire-engine. This was the precursor of the steam fire-engine. A good number of men operated the machine, and pumped water out of the reservoirs into the engine, and thence upon the fire. Motor-driven fire-engines have succeeded steam driven, just as steam succeeded hand-working. In most mills, whether new or old, upright water pipes are laid in the corners of the staircases from top to bottom. On each landing there is a nipple, to which can be screwed a hose pipe, the latter being then carried to the scene of action in case of fire. The pipes may be either coupled to a steam fire-pump or to an efficient supply of water, such as the town's mains or the reservoir, when at a sufficient height. In a certain case known to the writer, hose pipes were coupled to canal water at a lower level than the fire and wonder expressed that the water did not lift of itself. In another case, the water of town's main had not sufficient force to lift up to the fire.

Sprinklers.

By far the most distinctive and efficient application for the extinguishing of fires is found in the employment of sprinkler heads. There are several leading types of these, but in all cases a good number of pipes are arranged above the machinery and the operatives' heads, and are kept filled with water from a large tank situated at a good height, or else from the town's mains or other efficient supply. The sprinkler heads should be arranged about 10 feet apart, so that the sprays or discharge from adjoining heads will easily touch each other. All specially dangerous places—such as wheel boxes, rope races, etc.—should have extra sprinkler heads. Rules are given by the insurance companies with regard to certain proportions and dimensions to be maintained in putting up sprinkler installations. For instance, the base of the tank should not be less than 15 feet above the highest sprinkler head, so that the water can be ejected with sufficient force out of the highest sprinkler head—say, a pressure of not less than 7 lb. at this point. Tables are also given regarding the capacity of the

tank for holding water. For instance, when the greatest number of sprinkler heads on any one floor exceeds 200, the minimum capacity of the tank must be 7,500 gallons. A rather striking part of every sprinkler installation is the application of an alarm gong outside the building, and arranged so that if the pressure of water falls by any means the gong is sounded. If, for instance, a fire were to occur in the night time, not only would the heat melt the fusible part of the contiguous sprinkler heads, and so allow the water to issue with considerable force upon the exact location of the fire, but also the gong would give the alarm to the surrounding neighbourhood. The small sprinkler heads are mostly based on



Figs. 148 and 149.

the original Grinnell type. In all sprinkler arrangements there should be two sources of water supply, one of which is practically unlimited. Indicators are fixed by which the pressure of water in the pipes and the depth of water in the tank can be easily gauged. Sprinklers have received very extended application, and the insurance companies make a very considerable reduction in the premium when sprinklers are adopted. The fusing point of the sprinklers may be 155° F., although it may be, say, 160° F. before the sprinklers really go off. Leakage of water from pipes or valves may ring the alarm bell and cause needless annoyance.

The Grinnell sprinkler head is shown in Figs. 148 and 149.

Fig. 149 is a view of the sprinkler closed: Fig. 148 represents the sprinkler open for the discharge of water. A solid half-inch stream impinging upon the deflector spreads in a profuse shower in all directions.

The peculiar and distinctive feature of this sprinkler is that the

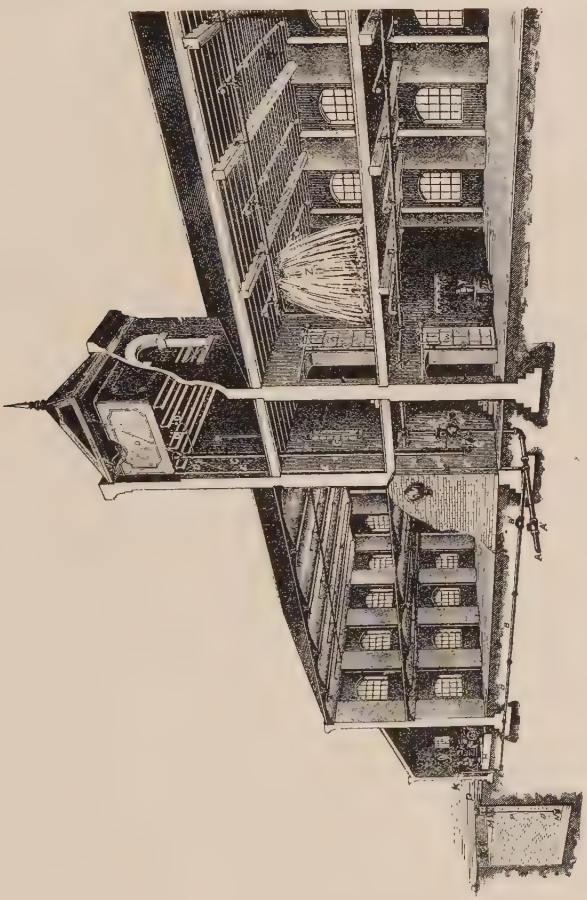


FIG. 150.

valve is seated on a flexible diaphragm, and is held in a manner calculated to relieve the low fusing solder of much of the strain.

Fig. 150 represents a long section of a low factory showing arrangements of pipes, valves, and water supplies for Grinnell automatic sprinkler.

Fire-Proof Doors.

Ordinary iron or steel doors to spinning-mill rooms for the prevention of fire spreading, have in many cases of recent years been displaced by composite fire-resisting doors.

Such a composite door is a built-up affair, in which two or three thicknesses of suitably prepared timber may be fitted at right angles to each other, and the whole covered with sheet steel, soldered on to thoroughly encase the wood centre. The steel plates exclude the air, the timber is of a slow-burning nature, so that the internal wood body only chars with contact to the steel casing plates even when the latter become extremely hot in the case of fire. Burning or charring may form charcoal which gives additional resistance to fire.

The fire-proof doors are sometimes arranged to swing on hinges in the ordinary way, but for spinning mills are perhaps better made and fitted on the sliding principle, arranged to close automatically. While appearing somewhat ponderous and heavy to the eye, the special construction of these composite doors, prevents them from being really so very heavy.

Trap doors for cotton rooms are not as much used as formerly, but both these and the doors may, if desired, have fusible link attachments for automatic door closing in case of fire.

Sprinklers and Insurance Requirements.

Fire loss may be covered by insurance, but often fails to compensate for loss of business.

The author has been in touch with the results of spinning-mill fires in which water damage has exceeded the fire damage.

Cotton-spinning mills often reduce their insurance premium from 30 to 45 per cent. by putting in effective sprinkler installations.

One sprinkler head may act on 100 superficial feet of floor area. Pressure in town's mains, pumping arrangements, and height of sprinkler tower, are three methods of maintaining sufficient discharging force at each sprinkler head. It is possible for such a pump to start automatically by means of the variation in water pressure in the pipes.

For more than 200 sprinklers on one floor there may be a tank capacity of 7,500 gallons.

To prevent water damage when a sprinkler head is injured or wrongly started off, some firms keep a rubber or pipe extension, coupled to a large ton-dish mouth so as to catch the water and discharge it through the window or other safe place.

The Grinnell.

The first "Grinnell" sprinkler head was invented in 1884, the name being that of the inventor. Many other types of sprinkler head were shortly introduced but the Grinnell type, with various modifications, has remained a great favourite. The sprinkler head itself—always small—is the fundamental item of any installation, since arrangements of water pipes, valves, water connections, water supply, are determined largely by local circumstances.

Fusible links have almost from the first been stated to fuse at 155° F., although it is not to be relied upon that a sprinkler head near the ceiling of a room will always go off when the local heat reaches exactly 155° F.

It is stated that the figures marked on sprinkler heads refer to the melting point of the fusible solder in water, and do not mean in the air in a mill fire; a higher temperature than 155° F. near the mill ceiling, would mostly be required to fuse the solder and start the sprinkler.

As sprinkler heads go, the Grinnell has often proved its value in regard to such items as

1. Security against water damage by breaking of the solder joint, or other defective action.
2. Certainty of action when needed.
3. Security against leakage and untimely operation.
4. Readiness of renewal.
5. Neatness and smallness.

The cotton man will understand that sprinkler heads such as the Grinnell are to be found in many kinds of large shops, warehouses, stores, other establishments and premises all over the world. English makers of the Grinnell are Messrs. Mather & Platt, Ltd., Park Works, Manchester.

The valve of the Grinnell sprinkler head is formed with a disc of glass which has a smooth surface, non-corrodible, seated on a flexible German silver diaphragm which is held in a state of tension so as to exert a constant force which, on the melting of the fusible solder link, throws the valve from off its seating.

The valve is held in position by means of a strut formed of three pieces held together by the fusible solder. The solder on melting lubricates the parts and thus helps in the breaking up of the joint. The hard metal key in the solder joint is designed to prevent the gradual yielding of the solder through the action of the water, the spring diaphragm, or any accident. The simple star deflector has stood the test of time and numberless experiences, in helping to give an excellent spreading and distribution of the water when required.

Since sprinkler installations are arranged on the basis of so

many feet apart, in any direction, the water spread is very important so that the water from one small head shall reach to the water from adjoining heads and cover all the danger space.

When the solder is fused and the valve joint is released, the water in the pipes pours forcibly upon the star deflector plate and spreads outwards in the form of a spray.

There are some half-dozen other makes of sprinkler head accepted by the Insurance Companies.

The Hoffman Sprinkler Head.

In this well-known example, the valve of the sprinkler is stated to be made of specially selected "Whitby jet," and said to be unaffected by acid fumes, or frost, and is incorrodible. It is claimed there is no chance of the valve sticking in its seating and that the joint is ordinarily destructible only by fire. The diaphragm of the valve is made of nickeline and of the spring type to quickly throw off the valve in case of fire fusing. The diaphragm is prevented from corroding by having a coating of tin or babbit metal.

Two valve levers are used, one being termed the well lever and having two holes corresponding with holes in the other lever. There is a lock key having prongs which are pushed through the apertures, the parts being then pressed together to form a joint which becomes broken when the solder fuses under sufficiently high temperature.

Fire Extinguishers.

Buckets of water, hand pumps, pitchers, jugs, cans, and other small vessels containing water, ordinary buckets, specially built fire buckets, mops, specially constructed brushes, sand, chemical fire extinguishers of many sizes and shapes. All such have been more or less used in cases of small fires.

Ordinary buckets of water have been used in numberless cases and will doubtless continue to be used to extinguish fires at the inception, and no patent or special forms can stop this kind of utility, although cotton mill fires are usually immediately beyond their scope. Water from buckets may be thrown 8 or 9 yards by an average man. Mops have often proved useful in small fires. Tests have been made upon heaps of straw, celluloid, oily rags and waste, packing cases, wood laths, cotton waste. A small quantity of plain water vigorously applied will usually extinguish a fire of most materials.

Burning spirit or petrol does not come under this category, but these will yield to asbestos cloths and sand either in extinguishing small fires or restricting the same.

When steam is available in sufficient force it will quickly tend to extinguish fires of volatile spirit.

For ordinary small mill fires well lidded buckets help to keep the water clean. Before now leathern fire buckets have been used on account of tightness.

Humidifying in Card-Rooms and Spinning-Rooms.

It is well known that a warm, humid atmosphere is the best possible one for the purposes of spinning cotton yarn. As regards the warmth, this has long been easily enough attained by arrangements of steam pipes, and for many years past wrought-iron pipes of small diameter, and heated with high pressure steam, have been generally employed. Although there are differences of opinion as to the proper temperature of a room there has been no difficulty in getting the degree of heat required, and while some are satisfied at 75° F., some fine spinners will stop at nothing short of 100° F.

The humidifying of a room has been a more difficult matter, and opinions vary amongst spinners as to how far artificial humidifying is a success. The chief advantages in a spinning room are that the cotton will work better, and having more elasticity will spin better and give better yarn. This is especially prominent on dry, hot days, or on days in which dry east winds prevail or even frosty weather when combined with a proper amount of heating. In the card-room there is less need of humid atmosphere, and furthermore there is some danger of rusting the card teeth of the carding engines or the needles of the combers, with reckless use of humidifiers. Sometimes, however, the want of humidity is felt more severely at the comber than anywhere else, and the humid atmosphere must be obtained even if needles and bright metal parts slightly suffer.

A humid atmosphere absorbs and destroys the effects of the electricity created by the friction of the belts and various working parts of the machines. Electricity makes the fibres curl and become intractable by creating mutual repulsion amongst them. Atmospherical electricity tends to make cotton curly and intractable.

Nature of Humidity Required.

There can be no doubt that the best condition of atmosphere for cotton growing, cotton spinning, and cotton weaving is a warm, moist one, these two conditions appearing to be essential in order to get the best results out of the cotton fibre in practically all stages of its cultivation and manufacture. As regards heat in cotton spinning from 70° to 90° F. may be fixed as most usual, although these limits

are often exceeded, either one way or the other. According to the heat of the rooms from 50 to 62 per cent. appear to be the best conditions of relative humidity for a spinning mill. It must be understood that relative humidity is the thing to be considered, and that it equals the ratio of the absolute humidity to the maximum humidity.

Humidity, of course, implies moisture or dampness, and in many cases it is considered that the amount of moisture which appears best for the cotton fibre is injurious to the health of the operatives and to the bright metal parts of the machinery.

Best relative humidities have been fixed after repeated experiments by experts as being the best for spinning mills, and considering both cotton fibre, machinery, and operatives.

It must be understood that the greater the heat of a room the greater the amount of absolute humidity required in order to reach the same amount of relative humidity. Heat alone is not sufficient for good spinning, and experience has long since demonstrated that dry, hot summer days are liable to give very bad work at the various stages, owing to the parching effect of the heat on the cotton fibres, and also because of the fibres becoming more susceptible to electrical influence.

Maximum humidity is the actual weight of aqueous vapour the atmosphere is capable of holding without reaching dew-point or dropping-point.

Absolute humidity is the weight per cubic foot of aqueous vapour actually present.

Relative humidity is the ratio of absolute to maximum.

If an atmosphere under given conditions will hold 8 grains per cubic foot and only has four absolute, the relative will be 4 : 8 or 50 per cent.

Humidifiers.

Since about 1890 various methods of moistening the atmosphere by specially constructed apparatus have come strongly to the front. On most days of the year, however, the atmosphere of the spinning districts of Lancashire is so naturally humid that many mills have not yet installed moistening apparatus.

In some cases water is forced by means of special pumps at a strong pressure through small apertures, and the water impinging against a fixed surface is broken up into an infinite number of fine particles so as to humidify the surrounding atmosphere. Such an arrangement is shown in Figs. 151*a*, 151*b*.

In other cases air is blown over or through water and the moistened air is injected into the rooms.

In still other cases water is placed in open troughs and allowed

to evaporate, this evaporation in some instances being assisted by running steam pipes through the water.

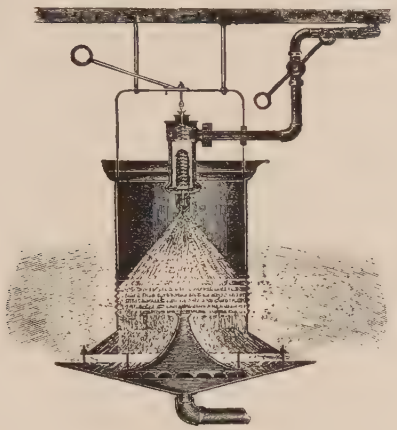


FIG. 151*a*.

We illustrate an apparatus of the first kind. These appliances are arranged at intervals in a room, say one to each pair of mules.

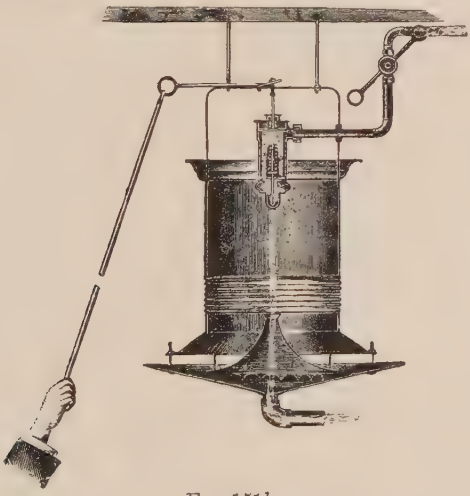


FIG. 151*b*.

Fig. 115*a* shows the apparatus at work, while Fig. 115*b* shows an arrangement for cleaning it and washing it out at intervals.

The Hygrometer.

Many mills use what is called a hygrometer, or hygrophant for testing moisture. By means of this instrument the amount of relative humidity present in a room can be readily ascertained—that is to say if it be a good standardised instrument, constructed on sound principles, and placed in a proper position. Some hygrometers have had the wet bulb and dry bulb too close together, and have not been placed in a sufficiently central position. It may be explained that an instrument of this kind consists of two thermometers, one of which as usual registers the temperature of the room, while the other has its bulb more or less covered with a thin piece of muslin cloth attached to a strand of material which is connected to a small well of water. The moisture absorbed by the strand causes the wet bulb to indicate a less amount of heat than the dry bulb, because the evaporation of the water from the muslin abstracts heat from the wet bulb and reduces its reading. There may be supplied with the hygrometer a printed table, so that by comparing the difference between the readings of the wet and dry bulbs with the table the relative humidity can be ascertained quickly. In some cases the relative humidity is shown directly.

The principle of action of the instrument is this: When the surrounding atmosphere is very humid little moisture is absorbed from the muslin of the wet bulb, and therefore little heat is abstracted from the bulb, as the one follows the other. A dry atmosphere absorbs more moisture from the muslin, and reduces the temperature of the wet bulb more. It follows that the nearer the readings of the dry and wet bulbs are to being equal the more humid must be the atmosphere surrounding the hygrophant.

Hygrometers are now made in which the relative or working humidity is at once indicated without reference to any table (see Fig. 151*c*).

Effect and Amount of Humidity.

The chief object of artificial humidifying in cotton mills is as follows:—

To modify unfavourable atmospherical conditions so that the cotton will work better and pass more tractably through the various machines, more especially at all processes and machines subsequent to the carding engine.

Many tests have proved that a smoother and stronger cotton yarn can be produced and better spinning obtained from a reasonably humid atmosphere than from very dry conditions. Somewhat unfortunately, humidity is not better for the bright metal parts of spinning machinery as it is for the cotton fibre itself, since the latter

in its natural state contains a certain amount of moisture, and works all the better when this is retained.

Both strength and elasticity of cotton yarn suffer when the atmosphere is very dry.

For cotton mills the following conditions may be taken as representing quite a sufficiency of moisture.

For all positions up to and including the carding engines about 60 per cent. humidity with dry bulb at about 72° F. Combing, draw-frames and fly-frames much the same as above or if anything slightly more, say 62 per cent. humidity, 76° F. dry bulb.

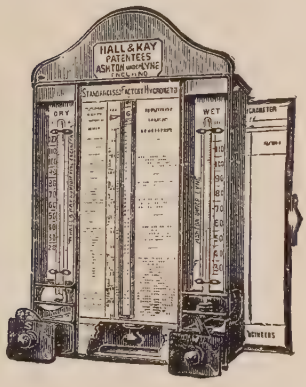


FIG. 151c.

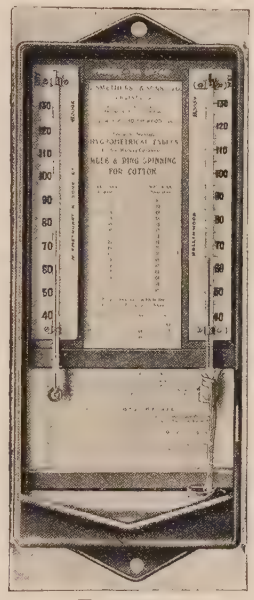


FIG. 152.

Rather more heat still for the mule and ring-spinning rooms, say for medium counts 53 per cent. humidity, 80° F. on dry bulb. Fine mule spinning 50 per cent. humidity, 90° F. on dry bulb. Winding, warping, beaming are perhaps better with reduced heat and increased humidity, say about 66 per cent. humidity, and 75° F. for heat. Conditioning cellars are perhaps best ventilated and registering as much as 84 to 88 per cent. relative humidity with dry bulb about 70° to 75° F.

Booklets on humidifying in cotton mills have been published by Messrs. Dobson, Winward, and several makers of apparatus for humidifying.

Artificial humidifiers have made it possible to spin and weave cotton in sections of the American Continent previously deemed quite unsuitable. It is claimed that in some parts of Massachusetts, and especially in some sorts of weather, carding engines can now be started promptly and well every morning. Whereas formerly it sometimes took an hour or more to get some of them running well. This statement is equally true of some other places.

The following names of American systems of humidifiers were quoted just prior to the war.

Carrier, American, Bentz, Bell, Dupuis, Cramer, Turbo, Tillotson, Hygrosso, Garland, Kelly.

In England we have such makers as the following: Hall & Kay, The Drosophore, The Vortex, Smethurst's, Howarth's.

The testing-room at Bolton Technical School has contained since 1910 a strength tester invented by Mr. Briercliffe designed to test single rovings and single yarns; one of these instruments was used in 1913 by a gentleman who made the following tests:—

"As the bobbins are arranged in the creels of the frames they are in excellent position for receiving moisture, that is, if the atmospheric conditions in the card-room are such as to give it to them, otherwise they are similar to being in a drying rack. To illustrate the point to show what effect humidified air has on the strength of rovings and yarn the following tests were made:—

"*Roving Tests.*

		Breaking Strength. Oz.	Breaking Strength. Drams.	Elongation in Inches.
1	No humidity. Bobbin from dry card-room	—	$6\frac{1}{2}$	$\frac{1}{4}$
2	Humidified $\frac{1}{2}$ minute	—	$13\frac{1}{2}$	$\frac{3}{8}$
3	,, 1 ,,	1	3	$\frac{7}{16}$
4	,, 2 ,,	2	12	$\frac{11}{16}$
5	,, 5 ,,	4	4	$\frac{3}{4}$

"Because of the twist in the yarn it is not so sensitive to the atmosphere and electrical tension as are the rovings in the card-room. Yarn being harder does not show the same increase in strength, but the following tests appended below show the results of a moist atmosphere:—

"*Yarn Tests.*

		Breaking Strength. Oz.	Breaking Strength. Drams.	Elongation in Inches.
1	No humidity. Cop from dry spinning-room	2	11	$\frac{5}{8}$
2	Humidified $\frac{1}{2}$ minute . . .	3	5	$1\frac{7}{16}$
3	„ 1 „	3	8	$1\frac{1}{2}$
4	„ 4 „	3	8	$1\frac{1}{2}$
5	„ 8 „	4	0	$1\frac{1}{4}$

"*American Systems,* 1913.

"No. 1 system uses water under pressure supplied by a pressure pump through pipes to heads distributed about the mill. Some of the water is turned into spray inside the head by impingement, the balance flowing back to the pump by gravity to be used again, while the spray emits from the casing of each head into the room.

"No. 2 system consists of a casing surrounding cloths stretched vertically on frames. Water, passing over the cloths, is absorbed by air from the room, blown through the casing by means of a fan located in the side of the casing and driven either by a belt or a small electric motor.

"No. 3 machine blows air by means of a small fan through a chamber, the bottom of which is filled with water. Submerged in the water is a steam coil for winter use. The air is impinged on to the surface of the water by vanes, causing a washing and mixing effect.

"No. 4 system is a central humidifying plant, using the old idea of the central fan heating plant to furnish humidification alone or humidity and heat combined. The system comprises one large central fan, an air washer and humidifier, separator, heating stacks or coils and flues or ducts to distribute the air to the various rooms.

"No. 5 system is similar in principle to the No. 1 with modification as to design. The same house also markets a central fan type of installation like the No. 4. Two of above systems furnish heads with individual fans attached to increase the air circulation, thereby increasing the capacity of the individual head.

"No. 6 humidifier is a specially designed steam valve to emit live steam into the rooms from steam pipes.

"No. 7 head works on the atomiser principle, similar in principle to the nasal douche. Two pipe lines are required, one for compressed air supplied by a central air compressor, and one for water not under pressure.

"No. 8 head is operated either by belt or small motor. A portion of the water flowing upon a rapidly revolving disc is turned into spray. The water not disintegrated is drained off by gravity, while the spray is picked up by air from a fan mounted on the same shaft as the revolving disc.

"No. 9 is a compressed air head, only the air and water are both under pressure, joining together and travelling in the same pipe a few feet until they come to the head itself, where atomisation takes place by impingement on a small metal disc.

"No. 10 principle is that of a fan and brush within a circular casing. Water fed to the brush is disintegrated and picked up by the air from the fan. The fan and brush are both on the same shaft, and may be run either by motor or belt.

"No. 11 is another of the compressed air family. There are two pipe lines, one for air and one for water, and the water is not under pressure. This head works on the principle of the injector plus that of the turbine, water being lifted an inch or two out of the water pipes into the heads and there pulverised by the high initial velocity of the air due to its pressure.

"There is certainly a wide range of principles of operation from which the possible purchaser may choose.

"First, the damp climate of Lancashire, England, where it was thought no artificial humidity was required, then the watering pot to wet the floors, the troughs of water in the floors, the steam pots, and all that. One fact of passing interest, however, is that the mills located in that same favourable climate of England are putting in humidifiers, and have been for some years. They do not need artificial humidity so many days in the year as in America."

Smethurst "Air Fountain" Humidifiers.

A generating set may serve for eighty air fountains, which will do for the whole of a full-sized cotton spinning mill.

The generating set comprises, belt driven air compresser with two cylinders, six air-cooling oil separators and condensers, and two horizontal receivers and air cleaners.

This set is guaranteed by the makers to discharge into the atmosphere 8,000 lb. of drinking water per day of 10 hours if required.

The specific aim of the air fountain humidifier is to produce humidification of the atmosphere, rather than to combine the several possible functions of heating, ventilating (possibly cooling) and also humidifying. It is stated that the construction is such as to obtain durability and the minimum of attention, consisting roughly of 85 per cent. cast iron, 5 per cent. solid brass, and 10 per cent. wrought tubes.

Many parts of the world are much worse off than Lancashire in regard to natural humidity, and in America, for example, in some parts much more benefit is obtained from artificial humidifiers. Even with us there are the dry frosts of winter, the cold wet days of autumn and early spring alternating with dry frosty east winds, and excessively hot dry summer days. All these have particular effects on cotton and cotton processes, and a well controlled, effectively applied humidifying installation helps in obtaining uniform mill interior conditions. A few days before reading this note the writer was in a noted fine spinning mill fitted with Hall & Kay's humidifier which in one room had been suspended for a few days owing to alterations. Foremen and workers agreed in wanting it on again if only for the sweeter smell.

Smethurst Hygrometer.

It is important to regulate the atmospheric conditions of our mills as fully as possible, and good hygrometers are indispensable for indicating the humidity.

In the case of the new Smethurst hygrometer for cotton spinning the makers recommended a set of six, each being adapted to its own department.

No. 1. Serves for all processes from bale to lap.

No. 2. Carding, combing, drawing, and fly-frames.

No. 3. Spinning. Mule and ring.

No. 4. Winding, warping, coning, reeling, bundling.

No. 5. Conditioning cellars operated on the absorption principle.

No. 6. Warehouse and storage.

A valuable improvement in humidifiers of recent years has been the use of automatic regulation of the amount of humidifying.

Want of attention to obtaining uniform operation of apparatus was formerly a great obstacle to the progress of ventilating humidifiers.

Considerable efficiency has now been attained in such regulation, but results are better when there is abundance of evaporative capacity in the system adopted.

Spinning mills need abundant light, firm foundations, strong walls, good spaces, and are all the better for having an up-to-date humidifying installation.

Humidifying for Other Textile Fibres.

It is well understood that the linen industry of Ulster benefits equally with the cotton trade from a humid atmosphere, and this is to a considerable extent natural to the spinning and weaving centres. The present writer has been at different times inside

some of the Belfast and Ulster textile concerns and noted many points of resemblance as well as many points of difference.

It is said that some of the finest Ulster linens are yet woven on hand looms operated in selected positions and in this way obtaining a naturally humid atmosphere.

It is stated that steaming has been resorted to in some linen weaving mills to an extent that would astonish many Lancashire operatives.

"Wet" spinning is more general in Ireland as distinct from "dry" spinning, being especially suitable for fine linen yarns. Flax in its later stage may be taken through a hot water bath and the flax fibre is thoroughly saturated, so that modern humidifiers are not needed in the spinning-rooms but may be of distinct service in the preparing-rooms, quite the opposite of what is more needed for cotton.

In preparing flax very dry slivers have a greater tendency to coil round delivery rollers and not to enter the cans as satisfactorily as in a conditioned state. A good humidifying installation helps to clear the air from dust and fly and to improve the atmospheric conditions for both the material and the operatives. Steaming may be convenient in a steam-driven and steam-heated mill, but is accompanied by objections such as possible overheating.

Cleworth, Wheal Humidifiers.

Messrs. Cleworth, Wheal & Co. claim as follows for their humidifier:—

"The rotary screens adopted after exhaustive experiments lasting over two years, act very well in the thorough scrubbing to which they subject the air. Every particle of dust, dirt, and soot is removed and deposited in the base of the machine, where it can be easily and quickly removed.

"The rotary screens pass slowly through a few inches of water maintained in the base by means of a ball valve, picking up enough to keep them wet, and in its tortuous course through the screens the air naturally picks up humidity.

"Here is a simple method of humidification and ventilation that anyone can readily understand and attend to; no sprays, pumps, live steam, or loose moisture."

It was pointed out at the opening of the research institute at Didsbury in March, 1922, that the humid atmosphere which had done Lancashire cotton trade so much good, was now obtainable in other countries by means of artificial humidifiers, so this natural advantage has been greatly minimised. Perfection in automatic machinery has also reduced any advantage formerly possessed by Lancashire.

Extremes of heat can be endured better when the air is circulating and in movement, but extremes of cold are endured better when the air is still.

The temperature of a room is affected by the amount of air change. The greater the amount of heat generated by motors, quickly running shafting, friction in bearings, quickly running spindles, wheels, and pulleys, the greater the amount of air change renewal is needed.

Fig. 153.

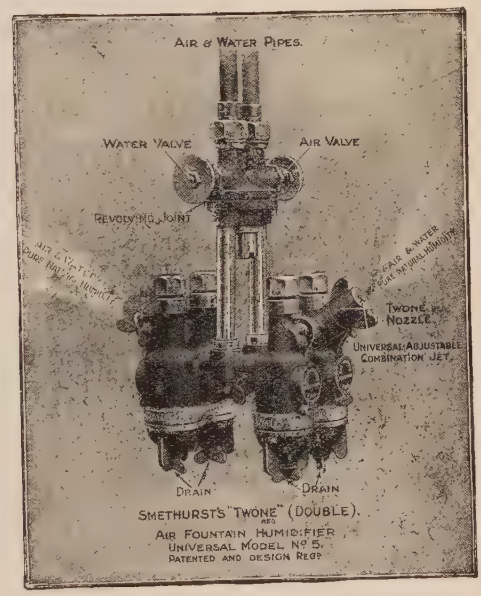


Fig. 154.

Fog Filters.

Fog is an enemy to cleanliness which permeates even into spinning mills, and blackens the lower portions of the cops when on the mule spindles, especially when the yarn counts are fine, and the cops remain a rather long time on the spindles, say from one and a

half to three days for fine twist cops. When fresh-air humidifiers are used without adequate air cleaners or filters, the dirty cop evil becomes more pronounced at any time and especially in mills placed in busy, smoky positions.

Fog filters or air washers are often considered part of a humidifying installation. Special filtering cloths may be stretched on frames, set in rows in the filter to an extent depending upon the volume of air to be dealt with. Each frame and each filter should be easy to get at and remove for cleaning or renewing purposes, preferably in the summer time.

Benzine washing of these cloths may be done occasionally, but often treatment by vacuum cleaners is sufficient. An air filler should intercept and retain dirt and dust particles, without occupying over much space.

The extent to which air cleaning cloths or other air cleaning material is used, depends somewhat upon the type of humidifier.

Uniform Conditions.—With sufficient and uniform humidity all textile fibres are softer, more pliable, and more adaptable to working conditions.

In very dry weather individual fibres are more ready to separate themselves at any stage, and are more ready to cling together under adequate humidity. A humid atmosphere tends to absorb atmospherical electricity, deal better with dust and fly, and suit mill conditions generally. *Per contra,* the assembly of too much moisture in special mill positions becomes a nuisance.

Constancy in heat and humidity are valuable in spinning mill processes equally with constancy in quality and kind of cotton, and in regard also to men and machines.

In connection with the use of artificial humidifiers one fact above all others has been impressed upon the author, viz. the importance of that amount of careful and faithful human attention which is required, and which because it is often left to a man who also has many other important duties, is sometimes neglected.

When saturated air is heated the relative humidity falls. It may be noted that it is possible to have super saturation to a condition not indicated by wet and dry bulbs.

Central apparatus forces air and water to the distributing jets or fountains of which one is shown in Fig. 154, and of which several may be used in one room. See also Fig. 155.

Principles and Methods.

Forcing hot or cold air through a film or very thin stream of water and thence forward into the mill rooms represents one basis of operations. Fans or pumps may be used for this.

Pump forcing of water through comparatively small apertures,

upon prepared surfaces, and into special distributing cylinders, represents another great fundamental principle in use by different makers.

Forcible meeting of air and water jets under strong pump pressure is a recent and successful method.

Evaporation of water from suitable trunks or pipes, perhaps assisted by steam pipes represents yet a third principle.

There are numerous makers of humidifying apparatus, each one introducing special features of detailed application, and utilising fundamental principles of collecting, cleaning, mixing, and distri-

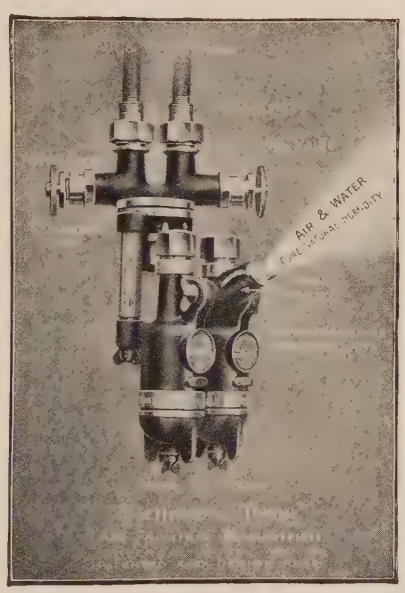


FIG. 155.

buting air and water to the best advantage. Usually such makers will supply ample explanations and leaflets to possible customers upon application.

A much used principle consists in vaporising a stream of water by an air jet.

Simplicity of construction and action, uniform operation, and not using more space than can be helped, are features to be aimed at. The Herbert Smethurst method is illustrated in Fig. 155, such instruments being distributed about the rooms as required, and operated from central apparatus.

It is desirable in water vaporising systems to have good control

valves, so that any water leaving the pipes or nozzles shall be acted upon by sufficient force of air to give effective vaporisation.

In some methods if the pressure of air for the moment is not sufficient to vaporise the water, then the water is automatically shut off and drain pipes are opened to clear the water way.

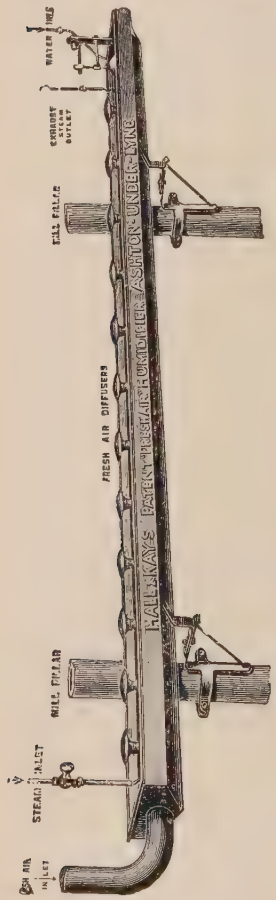


Fig. 156*a*.

In many cases the humidifying cylinders admit only water under pressure, and the air naturally rushes into and through the cylinder. More recent efforts have utilised pointed nozzles for the emission under force of air from one nozzle against water from a second nozzle, the force of impact being such as to vaporise the water and spread it into the atmosphere.

When watching this action the first time it appeared to the writer that moisture drops would injure the machinery, but many successful applications have been made.

What is termed the "air fountain" method has appealed to many people as a good system of spraying or atomising apparatus.

It is possible to dehumidify a room when necessary by temporarily altering the amount of heat or ventilation.

Good draining of water pipes will reduce danger of freezing and burst pipes and danger of dripping water from pipes, while helping to keep pipes clean.

Humidifying apparatus should aim to fulfil the following conditions :—

(*a*) A uniform condition of the atmosphere every day all the day over.

(*b*) An atmosphere containing moisture in a natural areform state.

(*c*) Atmosphere to be uniform in all parts of the room.

(*d*) Ventilation without draughts.

(*e*) Simple in construction, operation, and control, and not very liable to get out of order.

Requirements for Artificial Humidifying and Ventilating.

(*a*) To obtain and maintain a uniform and humid atmospherical condition in the rooms of the mill during all working hours and for all seasons of the year.

(*b*) The uniform conditions of humidity are required over large rooms and areas, with special provision for avoiding excess moisture or humidity in some rooms or parts of rooms, and insufficient humidity in other positions.

(*c*) There should be definite and satisfactory arrangements for cleaning the air and admitting it free from soot, dirt or fog.

(*d*) The air should be of uniform temperature, and ventilation

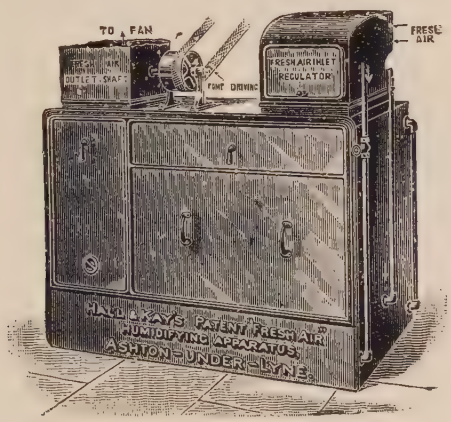


Fig. 156*b*.

should be adequate without draughts acting on the cotton in process or on the workpeople.

(*e*) Economy in first cost and in upkeep are always desirable and should be accompanied by simplicity in construction and operation, while attention must be paid to requirements of the Factory Acts.

Figs. 156 *a* and *b* represent portions of apparatus made by a well-known pioneer firm in this line of work, successful in many applications.

Fig. 156*a* a distributing trunk with extra fittings for conditioning.

Fig. 156*b* shows a central machine for receiving, purifying, and distributing humidified air.

CHAPTER XV.

COTTON WASTE AND ITS TREATMENT.

Kinds of Waste.

A ROUGH calculation gives about two hundred million lbs. of usable cotton waste annually produced in this country. A good deal of this is normally put into goods, which in the shape of rags is again made to yield up its fibre at a later date. At Bolton Textile school there are creel bobbins nine years old, which show the life of dry cotton. An ordinary spinning mill may yield a total waste loss of possibly 17 per cent. or so of which the far greater part is used again for one purpose or another.

Total direct loss is represented by moisture drying out of the cotton, and by sand, seed, leaf, and mineral matter.

In a good comber mill the total amount of usable waste is about doubled since the comber may give as much usable waste as all the other machines put together, although high prices have caused many spinning mills to reduce their waste per cent.

The least valuable kinds of usable waste are represented by blow-room droppings from beneath the cylinders and beaters, along with the worst sweepings. Often sold at so much per score of lbs. weight. The author has seen yarn 20 years old really good.

Bobbin waste, card strips, and fly and comber waste represent the best kinds of so-called cotton waste. It is really only so-called because it is put to most excellent use in other directions.

Chief items in cotton waste are as follows :—

Blow-room droppings, card-room, and spinning-room sweepings, cylinder and brush strips, and fly from the cards, sliver waste, lap ends, comber waste, bobbin waste, top and bottom clearer waste from various machines, cop bottom waste, bad cops, hand waste from mules and ring-frames, as well as from the later processes of reeling, winding, and weaving, crow-laps, stockings from long top clearers of fine mules.

A greater or less amount of this waste is used again in the same mill, especially in bobbin waste, but most mills sell the bulk of the waste for treatment by special machinery.

Condenser Waste Yarns.

In the production of yarns from cotton waste upon the condenser system no real attempt is made to place the fibres in parallel order, and indeed in many cases machines and parts of machines calculated to make the cotton fibres parallel is rigidly excluded from use at any stage. To take the most typical instance the roller and clearer card only is used, and what is termed the Scotch feeder is employed to transfer the waste from breaker to finisher card, so that the net result is a felting, crossing, condensing, and rubbing of the fibres into condenser strands which do not have any parallel order of the fibres. In like manner at the waste condenser mule, draft rollers are entirely omitted, nothing but carriage draft is used to make the yarns sufficiently fine, and this carriage draft is usually limited to drawing 4 into 7 or 7½. The twist per inch is also kept low. The net result is a hairy full thread somewhat resembling a worsted yarn, with the fibres felted and crossed in a manner very suitable for raising purposes, thus giving a yarn which will give a very full appearance and feel to the goods finally produced therefrom, with sufficient strength obtained from the rubbing and felting of the fibres, and by keeping the counts very low or coarse.

In spinning ordinary cotton yarns, not only are the fibres very parallel before reaching the mule, but the use of draft rollers—combined in many cases with putting up two rovings together—helps to give a smoother and barer yarn, and with sufficient strength, although spun to fine counts.

Quite a choice of final machines is offered to firms spinning yarns from cotton waste.

Example. — Condenser mule, preparation mule, fly-frame, ordinary ring-frame, false twisting machine, the Chapon spinner, and the can frame.

Waste Preventing.

At neither the cards nor the drawing-frames should any soft waste be made by cans choking up and running over, though of course the stop motions on the draw-frames will prevent most of that, but the card has no such protection.

The rollers on the drawing-frames should be always kept properly varnished to keep down the waste from lapping on the rollers and on the clearers. The roving bobbins on all the creels on fly-frames and spinning machinery should be always run off bare—this wants watching closely, as the average mill operative will make an excessive quantity of roving waste if not supervised.

Whenever waste must be made—and it cannot be avoided altogether—it should be kept clean, off the floor as far as is possible or picked up quickly so as to keep it clean; this applies with

much force to top and under clearer waste and to roving waste and all the different kinds of waste produced by carding.

One writer says: "The Chicago packer has boasted for years that nothing of the hog is wasted but the squeal, and the oil refiner might say that he loses nothing of the crude product but the smell. Sawdust which was once thrown away or burned up, has become more valuable than the solid lumber from which it is made, and the by-products of the refinery are worth more than the refined oil. As late as 1860 cotton seed, which represents two-thirds of the weight of the cotton crop, was thrown away as worthless, to-day cotton seed and its by-products form one of the most flourishing industries of the Southern States."

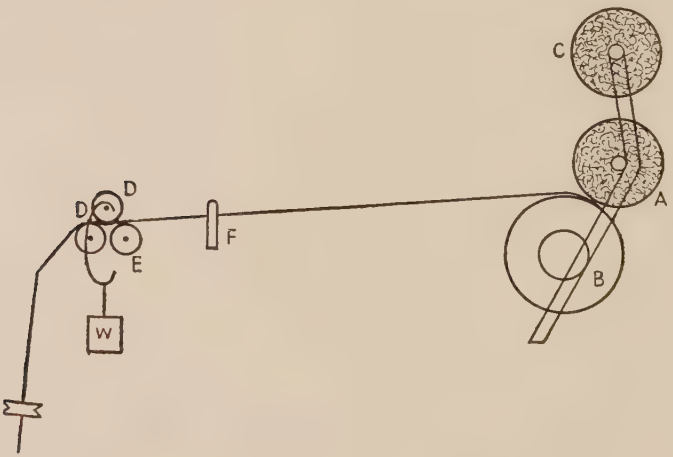


FIG. 157.—Passage of yarn in condenser mule.

Passage of Yarn in Condenser Mule.

The condenser bobbin A, containing 20 to 40 separate cotton strands, is placed on the corrugated tin drum B, and is slowly unrolled by frictional contact with B. C is a full bobbin in reserve. F is a cotton guide. DE are the rollers. W is the roller weight.

Roving Waste Openers.

Probably most spinning mills of any size now have at least one roving waste opener. This consists essentially of a quickly revolving cylinder containing a multitude of short steel pins which disintegrate the stringy masses of roving and reduce them to an

absolutely loose fibrous mass of soft, clean, but somewhat weak cotton ready for re-using. A feed lattice and licker-in, and a delivery connection to a mixing or to an opener complete the machine, the cotton roving being fed and delivered very slowly so as to give the main cylinder ample time for effective opening of the cotton.

Thread extracting machines for extracting hard ends from clearer waste of mules and ring-frames, are also used in some mills.

Some spinning mills reclaim their strips for re-use in same mill, others re-claim their comber waste, and some even re-card their strips as extracted by the vacuum strippers.

Waste Transactions.—Most waste, however, is sold to waste dealers who sort, divide, and grade, sometimes clean and re-classify and make up into soft or pressed bales according to requirements.

Waste dealers often contract for many months ahead with individual spinning mills and make either good profits, bad losses, or steady business, according to the way the market varies.

Waste from Certain Positions.

As regards the distribution and character of the waste, it may be said at once that it differs very materially in different parts of machines. In the scutcher the greater portions of the waste and impurities are found below the beater bars. The very numerous and powerful blows of the beater have the effect of causing the comparatively heavy seed, leaf, shell, dirt, etc., with some proportion of fibre to fall through the grate bars; the first of which is frequently set some distance—say half an inch or so—from the feed roller, in order to allow of the heavier impurities falling through. The droppings here are usually quite black looking with leaf, shell, etc., as compared with those elsewhere.

In the cavity underneath the cage bars is found a much less proportion of droppings, and it is whiter, with shorter fibre than the preceding, and the leaf is smaller. The grate bars, however, for this cavity have been more subject to differences in shape than the beater grate bars, and at the present time we have them laid at right angles to the sides of the machine, or parallel thereto, or in a herring-bone style, just as the case may be. Crighton's employed a travelling lattice called the leaf extractor at this point, the same idea being lately adopted by another machinist.

From the insides of the cages, and more especially from the upright box ends of the cages, and out of the exit trunks is gathered at times a smaller proportion of very heavy black dirt, consisting largely of very short and broken fibres which have passed through the interstices of the cages, along with fine dust and sand, the latter being the weighting part of this waste.

At the card the great bulk of the waste is formed either below the licker-in or as strips from the flats or the cylinder and doffer. The licker-in and its mote knives and under casings play practically the same part on the card as the beater plays upon a scutcher, and from beneath are taken out all the heavier impurities which have escaped the previous processes, such as seed, motes, leaf, etc. There should not be much short fibre or fly taken out at this point, and especially is this the case with modern metallic takers-in and the dish feed. The short fibre and fly are largely taken out by the flats, and, passing to the front of the card, are there stripped out by the stripping comb and stripping brush, and fall down upon the doffer cover. Fair amounts of strippings are embedded in the teeth of the cylinder and doffer, and are at intervals removed by the stripping brush used by the strippers and grinders. A comparatively small percentage of waste is gathered from beneath the doffer and the cylinder, but nothing near as much as was the case before the very general adoption of improved under casings.

Roller and Clearer Card.

Fig. 158 indicates rollers and clearers. One card may have 7 pairs of these workers and clearers over the cylinder. Attention

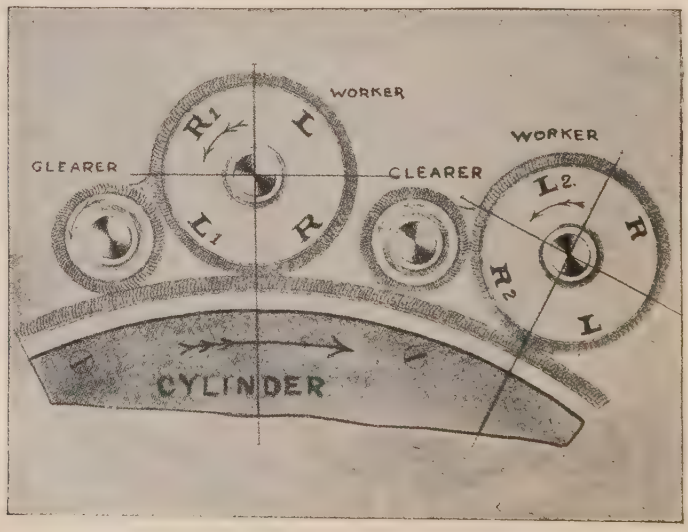


Fig. 158.—Roller and clearer card.

is directed to direction of rotation of each part, and the way the

card teeth are pointing. For a cotton waste card each clearer may be 4 inches diameter, each worker or roller 7 inches, and the cylinder 50 inches diameter. Each clearer about 200 r.p.m., each worker 15, the cylinder 70 to 90, the doffer 5 to 8. For new cotton spinning 20's the speeds would be doubled.

Proportions of Waste.

An approximately correct list would be somewhat as below :—

Opener	say 4	per cent.
Breaker scutcher	,, 2	,,
Finisher scutcher	,, $1\frac{1}{4}$	,,
Card	,, 5	,,
Draw-frames	,, 1	,,
Fly-frames	,, $1\frac{3}{4}$	,,
Spinning	,, 2	,,
Total,	17	per cent.

With good clean cotton the total waste may come out as low as 14 per cent., while with dirty, wasty cottons the per cent. of waste is increased.

When combers are used the average loss per cent. in waste for the comber alone may be taken at about 17 per cent.

If too much waste is put into the mixing at once, there is a bad effect on the lap, as well as upon the yarn.

The addition of waste to a mixing tends strongly to give lap-licking, because of its soft character. In proportion to the amount of waste put in with the good cotton the yarn becomes weaker, more irregular, and less compact, while the waste is very liable to again come out as waste at the various machines. The most common practice is to take bobbin waste back to the mixing, and a certain amount of this is often permissible, except in very good yarns.

With a large proportion of waste it is very difficult to keep "nep" and "slubs" out.

Waste in Mills Using American Cotton.

(*a*) From the openers and scutchers: droppings from below the beater bars and cage bars, and dust and dirt from inside the cages and dust flues. Little of this can be used again.

(*b*) From the cards: strippings from the flats, cylinder, and doffer; strippings from rollers and clearers, and from the ends of these rollers, if such are used; licker-in fly and fly from beneath the doffer and cylinder; sliver waste and lap ends.

(*c*) From the frames: sliver waste and bobbin waste, top and bottom clearer waste, waste from roller laps and broken rovings.

(*d*) Spinning waste, crow waste, top clearer waste, waste from roller laps, bad ends, waste from picking saddles and roller ends, bobbin waste, piecing-up waste.

In addition to the foregoing we might specify the following: cleaning waste or oily waste, sweepings up, old banding.

Broadly speaking, there are two principal classes of waste used in waste spinning: (1) Soft waste, which includes all waste made before the cotton has received the final twist at the mule or ring-frame. (2) Hard waste, which comprises all waste made after the cotton has been twisted at the final spinning process. The various kinds of waste are sub-divided according to cleanliness, etc. For some purposes it is better that the waste should be solidified a little by a "soaper," which is an appliance fitted to the cop bottom machine. In the blowing-room various kinds of openers are more or less in use containing anything from one cylinder, or beater, up to six or possibly even eight.

Rag Machines.

For the lowest counts of waste yarns as used in sponge cloths, cleaning cloths, and for other purposes it is customary to use low classes of soft cotton waste. Prices and conditions have sometimes favoured the use of rags instead of all cotton waste coming from cotton spinning mills. Fibrous waste is obtainable from rags and cloth clippings, either of wool, silk, or cotton. Best cloth clippings and waste garments sometimes yield up fibrous material used in coarse hosiery. Black rag linings, grey, bleached, other colours of hard and soft materials require sorting. Special machinery is available for the first treatment of waste and used up cloths in order to reclaim the fibre. High war-time prices made moderate fortunes for hundreds of rag collectors, such good prices did they get. Some cleaning cloths are called "silks" in the trade because of the occasional use of a limited amount of reclaimed waste from silk rags.

The rag-shaker may be the first machine and the rag-tearer the second machine for treating the rags. Later machines may be much the same as for cotton waste if only a moderate proportion of rags is used.

The rag-shaking machine rids the material of a good proportion of the dust and dirt, so that the sorters and classifiers can do their work much better.

In one make of rag-shaker there may be a cylinder of 36 inches width, fitted with 12 rows of pegs over and under which grids are placed. The heavier particles of waste fall through the grids, and

the lighter dust is drawn out by a fan, and conveyed from the machine by a dust trunk. The cleaned rags are then passed through a rag-tearing or grinding machine, by which they are reduced to a fibrous condition in the form of flocks. One machine consists of an enclosed swift, 28 or 40 inches in diameter and either 14 or 18 inches on the face, and provided with straight, hardened steel pins. The rags are presented at a slow speed to the action of the pins by two feed rollers, and the rapid passage of the pins tears them into small fragments and to a degree opens out the fibres. Portions not sufficiently opened are removed from the cylinder pins by a revolving fan or "biter" roller fixed above, and are returned to the feed lattice. Above the swift is a baffle plate, over which the more fibrous parts are allowed to pass. The heavier of these are thrown by centrifugal force down a sliding board into a bin, placed behind the cylinder, from which they are removed by hand to be subsequently re-passed through the machine. The lightest material in the form of flocks is deposited in a shoot below the swift, and is in a condition to be passed to a further opening machine.

The speeds of the cylinder will vary according to its diameter, and the nature of the material.

	Revolutions per minute.		
	Cotton.	Mungo.	Shoddy.
Cylinder 40 in. diameter	750	650	350
,, 28 in. ,, ...	1,000	900	500

The production will vary according to the texture of each fabric, that is the number of times required to pass through the machine before all the rags are reduced to fibre. Production in 10 hours :—

Cylinder.	Cotton.	Mungo.	Shoddy.
14 in. wide, 40 in. diameter . .	5 to 6 cwt.	8 cwt.	10 to 12 cwt.
14 ,, 28 ,, . .	4 to 5 ,,	7 ,,	8 to 10 ,,
18 ,, 40 ,, . .	7 to 8 ,,	10 ,,	12 to 14 ,,
18 ,, 28 ,, . .	6 to 7 ,,	9 ,,	11 to 13 ,,

Cotton waste machinery may be divided into four parts :—

1. Blow-room machinery.
2. Carding machinery.
3. Frame machinery,
4. Final spinning machinery.

Summary of machines more or less in use for treating cotton waste. These machines are never all used in any one mill, but from this list various arrangements are made to suit particular requirements.

Ring-doffer.

Rings of $1\frac{1}{8}$ in. were fillet B, alternate with rings of $\frac{5}{16}$ in. leather A. The cotton follows the wire rings, and naturally splits into about 30 strands for 7's yarn.

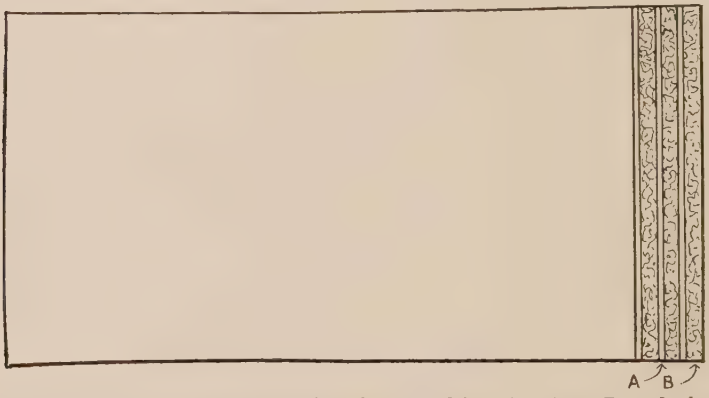


FIG. 159.—The ring-doffer, containing about 30 fillet wire rings, B, and about 30 leather rings, A.

Blow-Room Machinery.

1. The Willow. An intermittently acting machine for treating dirty soft waste or Indian cotton. For productions up to 9,000 lb. weekly or so. May be about 56 × 48 inches diameter in the main cylinder. Cylinder fitted with six or eight rows of blunt teeth, striking upwards against ribs or snugs in the top cover. May be used as a preparatory machine for hard waste to get rid of any loose dirt and hard substances.

2. The preparing machine. This is capable of greater productions than the Willow, and possesses a very strong cylinder and doffer. Sometimes used for hard waste before reaching the cop bottom machine.

3. The Crighton opener is sometimes used as a blow-room machine for soft waste or Indian cotton in a cotton waste spinning mill. The Crighton is too well known to need any further explanation here, but illustrations are given in Chapter I.

4. The cop bottom or hard waste machine is the chief machine for treating hard waste. It contains from one up to six or eight cylinders, each cylinder containing thousands of steel teeth, after the style of a bobbin waste machine. Each cylinder about 800 r.p.m. A six cylinder machine may operate about 5,000 weekly of cop bottoms from 26's to 36's American yarns. On cop bottom

machine the cylinder may be 21¼ inches wide or 19 inches wide in the teeth. I.H.P. about 15 per cylinder. A portable traverse grinding motion can be used for the cylinder teeth if required.

5. An ordinary scutcher fitted with a hopper feeder is frequently used to prepare laps of cotton waste ready for the breaker carding engine. If a lap has been previously made, the scutcher may double four laps. Choice of machines must be made to suit particular requirements.

6. For the finer condenser yarns ordinary cotton openers of any well-known type are occasionally used, especially when the waste has had a preliminary treatment.

7. Bobbin waste machines are not only used sometimes in waste mills, but often also in an ordinary cotton spinning mill. It is now possible to fit a hopper feeder to such a machine.

8. Thread extractors are specially designed to extract the hard yarn ends from crow-laps, clearers, or spinning-room sweepings.

9. The soaping arrangement is a simple device for automatically spraying the light fluffy waste from a cop bottom machine, with a thin mixture of soap water, in order to solidify the waste somewhat. Soaping gives rather a heavier yarn weight. Machines for carding and spinning cotton waste will be specified farther on.

Summary of Possible Systems for Treating Cotton Waste.

1. For spinning mill cleaning cloths to be frequently re-washed and the oil extracted.

The waste may consist of a mixture of chums, willowed fly, and sweepings helped by some strips or low-grade hard waste well broken up, seconds, condenser fly. Choice of processes and machines to suit any particular case.

Machinery selected from the following :—

Willow or else waste shaker. Crighton opener making laps. Breaker and finisher roller and clearer cards, connected by Scotch feed condenser making 20 to 26 ends of about 65 to 100 yards per oz.

As a final spinning machine use either the can frame, the Chapon, bobbin and fly-frame, or condenser mule. Equal counts of yarn for both warp and weft, or varied if desired. Cop bottom waste bought ready broken up if required.

2. For preparation yarn. 4's to 12's. Mixing of strips, cop bottom waste, Indian cotton, or lowest qualities of American cotton.

If the cop bottom waste is bought ready broken up any good double opener combined with hopper feed and lap-making attachment, would be almost sufficient in blow-room.

Use a Willow if any very dirty soft waste is used or possibly as a safety machine if a hard waste machine is used.

Breaker roller and clearer card to receive two laps.

Derby doubler. Finisher roller and clearer card fitted with manifold coiler delivery.

Slubber. Mule or ring-frame designed to take large creel bobbins and to make cops or bottoms of good diameter and length.

3. As an alternative preparation system use blow-room machines as per No. 2. Use only one roller and clearer card, and let it make only one sliver and take only one lap.

One or two passages of draw-frame.

Use both slubber and intermediate.

Mule or ring-frame to make large cops or bottoms. If a flat card be used instead of the roller and clearer it would be best fitted with a "fancy" roller beneath the back of the cylinder, and also side drawing at the front. When the faller plunge weights are very heavy it is possible to apply mechanism for locking the faller wires during the spinning process.

4. Condenser system for counts 1's to 3's from a mixture of condenser fly, and strips, blow-room and taker in droppings, clearer laps, sweepings.

Willow or other simple opener for the dirtiest of the wastes.

Combination carding set consisting of hopper feed, breaker roller, and clearer card, side drawing, Scotch feed, finisher roller, and clearer card, ring doffer condenser. Fly-frame to spin yarn or else condenser mule.

N.B.—For small productions and coloured waste it is possible to get waste ready to feed direct to the carding engine.

5. To spin condenser yarns from 4's to 9's or 10's cotton counts.

Waste of good quality such as strips, comber waste, and cop bottoms.

For the hard waste use a Willow for productions up to 8,000 or 9,000 lb. per week, or else the preparing machine for productions up to 16,000 or 18,000 lb. per week.

Then put this waste through a cop bottom machine of about six cylinders, fitted with a soaping arrangement.

Now make a mixing in desired proportions of the different kinds of waste, since the soft, clean waste need not pass through the above machines.

Next a lap-making scutcher fitted with hopper feeder.

Breaker roller and clearer card to take two laps. Derby doubler to make either half-width or full-width laps. Finisher condenser card, condenser mule.

6. Preparation yarns 4's to 16's from cop bottom waste, strips, Indian or low American, comber waste, in proportions according to the markets and results desired.

Willow and cop bottom machine for the hard waste.

Scutcher fitted with hopper feed.

Breaker card, Derby doubler.

Finisher card making four or six cans of sliver at one time, slubber, mule or ring-frame fitted with bobbin creel and three lines of draft rollers.

N.B.—The ordinary revolving flat card is a bad machine for cop bottom waste.

Proportions of different materials, and total amounts in a mixing, will be ruled by circumstances, such as relative abundance and price of material, and special result required in the yarn. Preparation yarns may be used for goods requiring hard wearing, but not fineness or high quality, such as some rope and twine, some kinds of towellings, woven belting, and tape.

Condenser yarns are required for goods in which a soft, full, woolly effect is desired, such as flannelettes, wefts in cotton blankets, quiltings, and carriage rugs.

If any firm desired to use bobbin waste for the better sorts of yarn, a bobbin waste machine might form part of the equipment.

If crow-laps or clearers from spinning machines, it might be advisable to use a thread-extracting machine.

Any mixing of cotton waste which has been treated with soap water should stand twenty-four hours before feeding to the carding engine.

The Willow has long been a favourite for first treatment of cotton waste, but what is termed the preparing machine is now often preferred because it will treat the cotton waste both more fully and more quickly, being equal in production to several ordinary single cylinder willows which may do possibly 6,000 lb. each. Either machine will give a preliminary treatment to hard waste, which will reduce fire danger and greatly facilitate the work at the next cop bottom machine.

Summary of Preparatory Cotton Waste Machinery.[1]

Machines more or less used in preparing cotton waste for treatment in a waste spinning concern may be specified as follows :—

1. Oldham Willow. 2. Cop bottom machine. 3. Crighton opener. 4. Single scutcher. 5. Breaker carding engine, with or without hopper feeder. 6. Finisher carding engine, with or without Scotch feed, and with or without condenser. 7. Derby doubler. 8. Occasionally a fly-frame with small diameter rollers.

A complete system in some cases consists of the following machinery :—

1. A six-cylinder hard waste or cop bottom machine, fitted with a soaping appliance.

[1] The author's "Treatise on Cotton Waste and its Treatment" may be referred to for fuller descriptions.

2. A single beater scutcher with hopper feeder.

3. Several breaker carding engines of the roller and clearer type, arranged to deliver the sliver into cans.

4. Derby doubler to prepare laps for the finisher card.

5. Finisher carding engines arranged with condensers to deliver the cotton upon long condenser bobbins, each containing about thirty strands or ends of cotton, every one of which makes a cop on the condenser mule.

6. The system is completed by using a condenser mule which spins yarn of 6's or 7's cotton counts.

The above system is very suitable for producing a round, level, full yarn up to 7's or 8's from cop bottoms or hard waste.

A second arrangement for spinning lower counts and qualities of cotton waste yarns may be specified as below, and is suitable for spinning from 1's to 5's cotton counts from soft waste, such as the best scutcher droppings, card fly, strips from the carding engine,

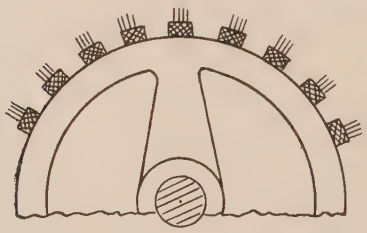


Fig. 160.

clearer laps, good sweepings, and similar wastes, upon the condenser system :—

1. Willowing machine with patent lattice feeder and special method of delivering the cotton.

2. Pickering machine.

3. Single beater scutcher with hopper feeder.

4. Single breaker carding engine of the roller and clearer type, fed by scutcher laps, and being connected by a Scotch feeder to the finisher card.

5. Single finisher carding engine fitted with ring doffer condenser, or else leather tape condenser as required.

6. Either cup-spinning machine, or else self-acting mule, arranged on the condenser principle.

The cop bottom machine is used for hard waste, because its cylinders contain multitudes of fine steel pins which open the cotton to a very minute degree. (See Fig. 160.)

Cop Bottom Machines.—For the treatment of hard waste, these machines occupy—and have long done so—a paramount position.

Above all other methods of opening and loosening thready or stringy waste, it is easy to adopt a hard waste cylinder machine to any amount of opening required, ranging all the way from one cylinder up to eight in the same machine. Cages should not be left choked up so that a back draft is set up and permit cotton to go round with cylinder.

Soap Water Machine (Fig. 161).

The soap water is brushed off roller A by the high speed brush B and upon the cotton going to the mixing.

Preliminary treatment by a willow or preparing machine reduces fire danger at the cop bottom machine, which has been more noted in times past for frequency of fires than any other machine in the mill. The back plate which acts as a stripper to

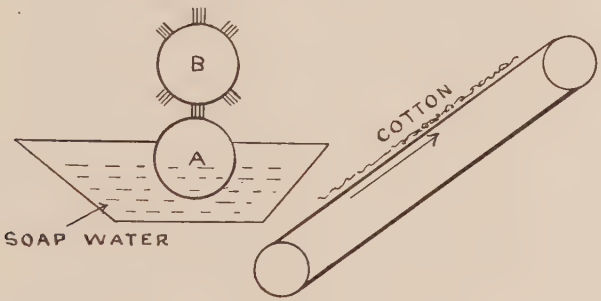


Fig. 161.

each cylinder may be set two or three card gauges from the cylinder to stop neps.

The use of sufficient cylinders, not over-feeding the machine with cotton, keeping up to the full cylinder speed of 800 or more r.p.m., making a correct mixing of waste in the first instance, keeping feed rollers well fluted and weighted, are all matters of importance in getting the cotton really well opened, free from hard ends and thready portions. Belts and bands to be all kept up to their full tension and driving power. Feed and delivery parts to be well set up to the cylinders. Like most opener and scutcher beaters these cylinders may be reversed at times so as to bring their reverse or unworn edges into striking action on the cotton. There are some who do this work every few weeks, as well as noting if any spiked sections need replacement owing to hooked or broken teeth.

Cop Bottom Machine.

The breaking-up machine used for converting the thread waste into fibrous waste consists of one or more sets of breaking cylinders and wire cages arranged in a series. The cop bottoms or hard waste are fed or spread by hand from the last machine on to an endless lattice, and delivered to a set of three fluted rollers (the first of the series). These in turn present the waste to the action of the breaking cylinder, which is of wrought iron, covered with lags provided with steel teeth. The dimensions of each cylinder are 21¼ inches wide over all, and 19 inches over the teeth, and each contains an aggregate of 9,000 to 11,000 teeth. From the cylinder the partly opened waste is drawn to the cages and passed to the feed rollers (one pair in this case) to the following cylinder. A machine may consist of one to eight, according to the class of material to be broken up. Or, if room space available is too restricted for this length, fewer cylinders may be placed to one machine and the material passed through a second or third time according to requirements. Much advantage accrues, however, from using one machine with the requisite number of cylinders. When there is sufficient work to keep a six-cylinder machine employed this is strongly recommended, and in cases where fine or hard twisted waste is to be broken even a seven or eight-cylinder machine is advisable. The benefits derived are principally increased production, economy in labour, and better work: for instance, while six single-cylinder machines produce 600 lb. of broken material from 32's cop bottoms, with six passages, a six-cylinder machine will produce 1,200 lb. of broken material, or double the quantity with one passage only, and open it more satisfactorily.

The saving in labour is self-evident, for as the material is delivered loose from the single cylinder, it requires six times the hand feeding on the lattice. In the six-cylinder in series the material after leaving the first cylinder passes over the wire cages to a pair of heavy rollers, where it is compressed, and thence conducted automatically to the feed rollers of the second cylinder, and similarly to the succeeding cylinders, all of which are driven at the same speed. In its passage through the machine from cylinder to cylinder the material acquires an evenness impossible with hand feeding, this contributing to the superior quality, while the augmentation in quantity is mainly attributable to the increase in speed given to the feed rollers at each succeeding part.

Breaking-up machines can be provided with fans for down-draught when dirty or coloured thread waste is to be opened. Also they may be fitted with a lap forming arrangement: 5 or 6 laps can then be placed on the feeder of the following breaking-up

machines. The cylinder shafts frequently run in ball bearings in order to effect a saving in power and oil.

To Produce 6's to 10's.

To produce slubbings suitable for spinning waste yarns for 2's, 6's or 10's counts. Kinds of waste to use, and arrangements of machinery.

Waste preparing and spinning machinery varies considerably, but the following systems would give reasonable results:—

For 2's counts we might use willowed fly, card fly, and strips, clearer laps. First of all an Oldham willow might be used, or else a Crighton opener, followed by a single beater lap forming scutcher fitted with hopper feeder. Breaker card on the roller and clearer principle, connected by a Scotch feed to the single roller and clearer finisher card. This latter may be on either the ring doffer or the tape condenser principle. The long condenser bobbins could be taken direct to either the cop spinning frame, or the condenser mule.

For 6's we might use a good deal of hard waste, such as cop bottoms, with card strips and clearer waste. To treat the cop bottoms it would be advisable to use a hard waste machine with picker cylinders, using from three to six cylinders, the soft waste being treated at first as per No. 1. Scutcher as per No. 1. Cards as per No. 1, unless we might prefer to use the Derby doubler instead of the Scotch feeder, in which case the breaker card would be fitted with a coiler and can delivery, while the finisher card would be fitted with a lap feed arrangement. The condenser mule would probably be the next machine after the finisher card.

For the 10's counts hard waste and comber waste might be used as the raw material, with preliminary treatment, as specified in Nos. 1 and 2.

For such fine counts either the ring doffer, the tape condenser, or the slubbing frame principle could be adopted. In the latter case we might use the Derby doubler between breaker and finisher cards, and the finisher card would be fitted with 4 or six card cans instead of the condenser. The cans of sliver or slubbing would be taken now direct to a slubbing frame fitted with three lines of small diameter draft rollers. The bobbins from the slubbing frame would then be taken direct to the creel of the mule or to a specially adapted ring-spinning frame fitted with drawing rollers. It will be noticed that this No. 3 system is a cross between the proper system of cotton spinning and the proper condenser system of waste spinning. No. 3 is termed the "preparation system," and may give a stronger yarn and cheaper, but does not give as round, full, and good-looking yarn as a well prepared condenser yarn.

Sorting Tables.

A practice which possesses some commendable features, but which is by no means generally adopted, is to employ long sorting tables for the waste, with or without gridded portions.

If various sorts of rather low grade wastes such as sweepings, willowed fly, are purchased it may pay to have these wastes placed on the sorting tables and picked over for bits of string, bits of metal, portions of cotton very inferior, or some very superior.

Willowed fly is much used for low counts of condenser yarn, and sometimes waste dealers have what they term seconds willowed fly, and some of this the writer has found to contain a good deal of undesirable material, unfit for putting into any machine or process. Sometimes this kind of work is done by waste dealers before re-selling.

If for wadding the best portions may be sorted out for the best face cotton whether it be for natural colour or for bleaching.

Fire Protection.

Fire protection is much needed in the earlier processes of a cotton waste mill, whether it be that wadding, gun-cotton, or condenser yarns are required from the mill.

Some machines are less liable to cause fire than others, such as the ordinary Oldham willow, whose blunt teeth and manner of their actions render this machine as safe as any to commence with.

Any make of hopper bale-breaker or hopper feeder is good since the tumbling about of the cotton in the feed box tends to liberate metal substances without fire risk. No parts of such a machine are very dangerous in causing fire. Blade or knife beaters or spiked cylinders having a good speed, are especially dangerous.

Kinds of Waste.

(*a*) Cop bottom, (*b*) low comber waste, and (*c*) greasy, soft waste and sweepings. Differences to make in the spinning of each variety.

(*a*) It is possible to open, clean, prepare, and spin cop bottom waste either on the condenser system or the preparation system, but in every case a good preliminary treatment of such waste is necessary in the hard waste breaking machine. For the most part such waste is made into good, level yarn of 5's to 9's counts on the condenser system, and the yarns are peculiarly well suited for and are extensively used as wefts in such cloths as quilts, bed covers, flannelettes, cotton blankets, and sheetings. If spun on the preparation system it may be bundled into hanks and used by

makers of rope and twine, or as warp in certain classes of goods, or as weft in cloths which may be printed or dyed, such as towels and cretonnes.

(*b*) Nearly all the remarks given about hard waste will apply to low comber waste, excepting in regard to preliminary treatment. It will spin, however, into finer counts of yarn, and is often only mixed in moderate proportions with the other wastes in order to improve the "mixings," and secure sufficiently good spinning and yarn. The greater the proportion of comber waste to hard waste the finer the counts or else better will be the quality of yarn. The uses of the yarns will be much the same, but in better qualities of goods. For the finer counts—but not necessarily better qualities —the cotton waste may be made into bobbins on the slubbing frame and spun upon the cotton system at the mule, this being often termed the "preparation" method of waste spinning, which will give stronger and more solid yarns of possibly finer counts, more suited for the purpose of warp or rope-making.

(*c*) When, however, we come to the use of greasy, soft waste and sweepings, these are frequently spun on the condenser mule into low classes of weft, say, from 1's to 5's counts, and used for sponge cloths, candle-wick and lamp-wick, cheap flocks for bedding.

The can spinning frame or the chapon is often used instead of the mule for spinning from 1's to 4's for coarse weft for cleaning cloths, etc., from sweepings. The weft yarn in the loom is unwound from the inside of the cop, and makes little waste, but requires a special shuttle, without tongue, and having a special cop holder in the form of a metal or rubber lid.

Lap-licking.—The method of running coarse yarn or rovings round with laps when forming at the scutcher in order to prevent lap-licking is much more necessary and more resorted to in waste spinning mills than in ordinary spinning mills on American cotton. The creel for the bobbins or cops should be out of the way, and the cops or bobbins as large as can be conveniently obtained.

In Fig. 163 in this chapter is shown a scutcher containing a special spiked beater which has a good combing action and having the more common system in waste mills of having a hopper feeder attached to the scutcher, since cotton up to this stage is almost always delivered in loose open form. Indeed in some cases of coloured cotton, small productions and low qualities and counts, the cotton is often taken in loose form to the back of the carding engine and fed there either on a hand-fed lattice or else by a hopper feeder on the breaker card.

The bobbin creel for preventing lap licking is often used in mills operating on new Egyptian cotton.

Wadding.

A somewhat severe bleaching process is needed when cotton waste or linters is to be used as wadding for surgical purposes. Processes may be included such as :—

Boiling in a good solution of caustic soda with the addition of a special solvent oil, washing, scouring with dilute hydrochloric acid, washing, hypochlorite of soda treatment, washing, scouring, drying. Finally treated by some kind of opening machine which loosens the fibres ready for the final treatment by the wadding card.

A roller and clearer card may be used with a comparatively simple delivery arrangement.

A drum is used at the delivery around which the delivered fleece is wound time after time until a sufficient thickness of wadding is obtained. The wadding is then cut across and stripped off. In some cases a folding apparatus is used instead of the fleece drum. The material may be put up in the form of rolls for retail purposes and containing a paper insertion previously added.

Absorbent Cotton.

Absorbent cotton for surgical purposes was a much used article prior to the war, and naturally the war led to an enormous demand for this, as well as for gun cotton which represents yet another important preparation from cotton waste.

Specific conditions are laid down for certified surgical wadding such as that it must be tasteless and without smell, insoluble to ordinary solvents but not to certain specified ones. Bleached absorbent cotton placed on the surface of cold water should exhibit a satisfactory tendency to absorb the water to a sinking condition, and in doing so the water should not give evidence of an alkaline or acid reaction.

Absorbent cotton properly made should be able to take up eighteen to twenty times its own weight in water, there being specified official tests for this.

Cotton Banding.—Cotton banding represents one of the uses of cotton waste, but is catered for largely by the trade in reject cops, cops which have been subject to fire or water damage, pulled cops, mixed cops, or, in general, any cops which have suffered damage in some way which unfits them for ordinary cotton cloth or other full-priced yarn uses.

Oldham Willow.

A single cylinder long-established machine specially suitable for treating dirty, soft waste.

The cotton can remain as long as desired under the action of the cylinder, which has a limited number of long blunt teeth not likely to cause fire.

One of the best machines for a limited amount of preliminary opening.

Strikes the cotton upwards against nogs or bars in the top cover.

Automatic timing to regulate feed and delivery of cotton.

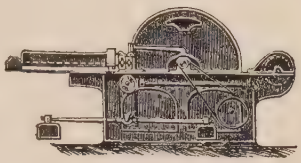


Fig. 162.—Oldham Willow.

Cotton Mixing.

A mixing of low middling American and Dhollera cotton in the proportion of two to one. Proportions of waste to expect (*a*) at the opener, (*b*) at the scutcher, (*c*) below the under casings at the carding engine, and (*d*) as strippings.

It is probable that the opener would make about 4 per cent. of waste, very little indeed of which would be of much use to anyone. We might reckon the waste at the first scutcher at about 2 per cent., and that at the second scutcher at about $1\frac{1}{4}$ per cent. The total waste at an ordinary revolving flat carding engine is usually somewhere about 5 per cent., and it is probable that this total does not vary a great deal whether the card be using low, medium or good American cotton. Furthermore, the percentage in some cases may be more for the better cottons than for the worst, or the opposite may hold good, according to the general conditions of the card and the manner in which the various parts are adjusted to each other. The author has personally known the waste to vary at the card between 4 and 7 per cent. Taking 5 per cent. as the basis for the descriptions of cotton under notice, it is probable that about 3·2 of this 5 would be due to the strips from the flats, cylinder, and doffer, leaving about 1·8 to be due to the under casings of the taker-in and cylinder and from below the doffer and lap and sliver waste.

Gun Cotton.—Clean cotton waste and linters, obtained from the delinting of American cotton, is probably the most used material for making gun cotton. These materials must be cleaned and broken up to whatever extent may be required, by one or another of the preliminary machines specified in this treatise. When all leaf, bits of seed shell, and other similar undesirable matter are removed, the natural cotton wax and oil may be removed by treatment with caustic soda. Gun cotton bleaching needs to be done to carry certain tests.

Comber Waste.—Light coloured comber waste from extra

stapled American cottons, and the lighter Egyptians, will not always suitably blend or mix together, and this is quite as important in its way for certain sorts of goods from cotton waste as in the finer yarns. Egyptian cotton as a whole will bleach well, but different shadings may be obtained if we are not careful, and the bleaching effect may come out differently.

If white cotton waste is dyed to imitate brown Egyptian then it is more or less spoiled for bleaching.

Comber waste of itself has a tendency to make a soft yarn or a soft wadding, new Uplands cotton makes a strong batting. Some makers of wadding use a certain proportion of ordinary Uplands cotton to put a face on the "batting."

In the case of the ring doffer condenser the author has seen excessive breakage of ends owing to long fibres or hairs reaching across on the doffer or on the divider and touching adjacent rovings.

Botany Yarns.

Apparently this name, occasionally applied to some cotton waste yarns, has been obtained from the wool trade, and appears to have been more especially applied to short wool yarns.

It has been said that its very first origination was from "Botany Bay." The term is sometimes applied to mixtures of short wool and short cotton or cotton waste spun on the condenser system.

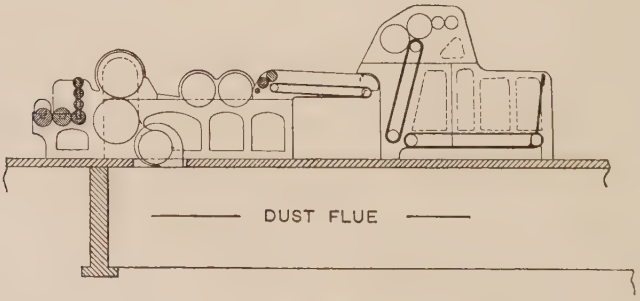


Fig. 163.

Single scutcher as made by Platt. Bros. when required, specially for cotton waste. Fitted with hopper feeder to take loose waste. Two beaters of which one has a multitude of fine spikes. Makes laps for the breaker carding engine.

Angola Yarns.

True Angola cloth is a light cloth made from the wool of the Angora goat—a native of Asia Minor. As made from cotton waste or mixtures of wool waste and cotton waste, the cloth is really an imitation angora.

Treatment of Hard Wastes.

In dealing with hard wastes which comprise cop bottoms, reeler's waste, doubler's waste, winder's and warper's waste, etc., the main difference is in the initial treatment.

The waste is usually first passed through the preparing machine, to give it a preliminary loosening and extract any foreign substance. Afterwards through a breaking-up machine sometimes called a cop bottom machine.

These machines break up the hard waste into a very fine fleece. The six cylinders are used mainly for treating cop bottoms, and all single waste. The doubled and cabled wastes are treated by the six or eight cylinder machine. On account of the very light fluffy nature of the waste delivered from these machines it is customary to put an automatic soaper at the delivery as shown.

As the material is very clean it is unnecessary to put it through a combined opener and scutcher, therefore it is customary to put this class of waste through a scutcher fed by a hopper feeder. Often comber waste is mixed with the hard wastes at this point. The breaker card for this class of waste is similar to previous description, with the exception that it delivers the cotton into a can although through the aid of the side drawing.

As these clean wastes are made up into better materials and higher counts it is more important to get regularity of counts. This is to some extent obtained by using the Derby doubler between breaker and finisher cards. Its object is to make a uniform lap for the finisher cards from ninety or more slivers from the breaker card. The laps are fed to the finisher card, and the only difference in this card for the clean wastes consists in having more ends to the ring doffer to suit the finer counts.

The 3-speed condenser mule is used with 1⅜ gauge of spindle as most of this clean waste is used as wefts for Union shirtings, suitings, and good quiltings. Also it is mixed with a proportion of wool and even occasionally alone for stockings.

Directing attention now to the preparation system, our aim now is to obtain a strong yarn for ropes, twines, candle-wick, lamp-wick, braid, and mops. The type of wastes used are hard wastes and comber waste treated at the cop bottom machine and scutcher exactly as previously described. Also they are passed through the breaker card, Derby doubler, and finisher card as before with the

exception in the finisher card that we have instead of the ring doffer, the quadruple coiler system. This means the fleece from doffer is divided into four portions by inserting three leather dividing rings $\frac{1}{4}$ inch wide on doffer. Each portion passes down a separate trumpet and into a separate can. The comber waste need not be treated by the cop bottom machine (see Fig. 164).

The cans are then placed behind a special slubbing frame, with small diameter drawing rollers and suitable to make bobbins of 9-inch lift.

These bobbins may either be used in a wide gauge ring-frame or a wide gauge mule. The most common gauge of mule for preparation yarns is $1\frac{1}{4}$ inch for the smaller cops.

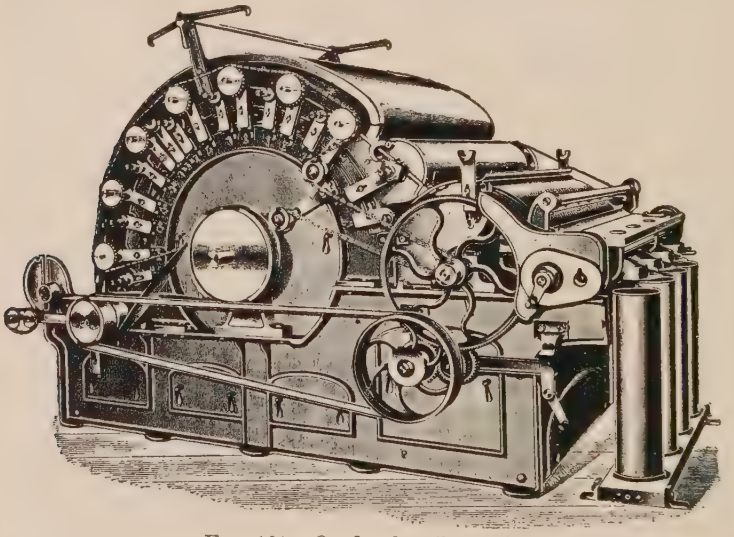


Fig. 164.—Quadruple coiler card.

The Roller Card.—The roller and clearer card is the accepted machine for treating cotton waste, and it is customary to pass the same cotton through both breaker and finisher cards.

Recently, a machine has been largely experimented with, for use instead of the breaker card for cotton waste.

An improved form of taker-in or beater arrangement is used, and suitable direct delivery connections and dust extraction appliances to this, all the roller and clearers being dispensed with. Economy of space, first cost, trouble and cost of working would naturally result from the adoption of this arrangement, providing sufficient opening, loosening, and cleaning of the cotton waste were

obtained. A returned mill manager from Russia has experimented largely in this direction.

The Flat Card.—The revolving flat card meets with little acceptance in the treatment of cotton waste. The present author has experimented largely in this direction, but with little success, unless a "fancy" be placed beneath the back part of the cylinder, the cylinder reduced in speed considerably, the doffer comb speeded up and kept in good condition, the doffer run slowly, the count quickly, and better still if side-drawing be adopted.

It is the writer's conclusion after much direct practical experimenting, that it is better to let the revolving flat card alone in a proper waste spinning concern. It may find a use in re-treating strips or comber waste—one or two in a large card-room filled with flat cards.

Hopper Feed to Breaker Card—Alteration of Counts of Yarn.

In some cases loose cotton is fed by special hopper to a breaker waste card.

In such cases of hopper feeders the counts may be altered in two or three ways. Say we desire to be coarser or thicker.

1. Heavier scale weights (see Figs. 165*a*, 165*b*).

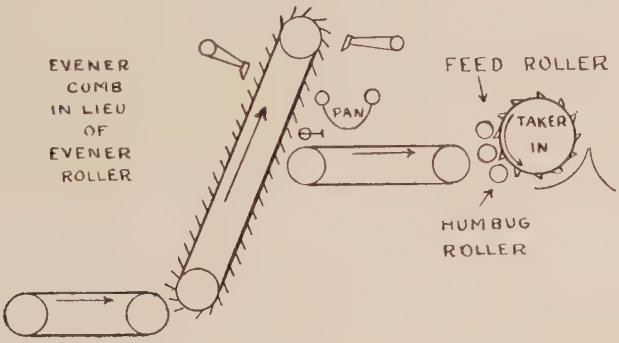


Fig. 165*a*.

2. Larger side shaft, change bevel to drive parts of feeding and delivery of hopper more quickly, such as, for example, opening the pan in a shorter length of time.

Note.—Setting evener bar farther away would fill the scale more quickly, but would not make it open more quickly.

3. A change sprocket wheel could be used to get a quicker speed of push-board and trip. For coloured materials and small mixings

of low-class waste the hopper feeder on breaker card is a great favourite, but it does not resemble an ordinary hopper for openers.

A hopper feed of this kind may be readily applied to almost any make of roller card, and usually contains four good adjustable feet which are adaptable to almost any kind of floor.

Cams and eccentrics, and one crank, are much in evidence to give

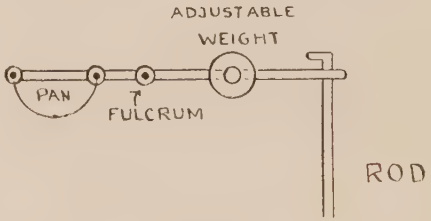


Fig. 165*b*.

oscillation of parts instead of rotation to such parts as evener-bar, stripping-bar, push-board, press-bar, to open the cotton scale, and to operate the automatic clutch.

It is the writer's experience that a very small alteration of the pan weight will make a distinct difference in the counts of yarn when the hopper is used as the initial part of a combined breaker and finisher card arrangement, having a Scotch feed, or a broad band feed to connect the two cards.

In setting the combers to the spiked lifting lattice, the latter is turned round until the joint or thickest part is opposite the comb.

Carding Engines.

In connection with the carding of cotton waste various mechanical arrangements are more or less in use, unknown to the *ordinary modern cotton spinning mill.*

1. Although long since rejected for ordinary cotton carding, the roller and clearer card is yet in very general use for cotton waste, and usually the same cotton waste is taken through two successive carding engines termed the breaker and finisher cards respectively.

2. Feeding two laps together for mixing and equalising is a frequent custom at the breaker card.

3. For small productions, possibly more for coloured cotton mixed wastes, and very low counts, we have sometimes the very novel feature of a hopper feeder for giving the cotton automatically to the breaker card.

4. Although metallic taker-ins are applied to cotton waste cards when required, a great many taker-ins on cotton waste cards have

the old leather fillet foundation for the teeth. The teeth are much more liable to injury, and the clothing can be more readily renewed, and will yield better to bulky portions of cotton or foreign substances than the metallic taker-ins.

5. Underneath the feed roller and the taker-in is usually a so-called Humbug roller of 3 inches diameter, covered with inserted wire, and used to help in opening the cotton waste and preventing the escape of too much fibre.

6. The feed rollers are often covered with wire to give a better grip to the short waste.

7. The rollers and clearers are much less liable to injury from lumps of cotton, and do not bring out waste the same as flats. They will lift in their bearings readily.

8. The whole top of the card is covered in with a bay-wood casing which keeps dust and fibre from escaping.

9. The rollers and clearers must be taken to a grinding machine once or twice a week.

10. *Side-drawing* delivers the cotton from doffer comb to a travelling belt about 5 inches wide with the calenders at the side or edge of the doffer (see Fig. 165*c*).

11. In many cases the breaker slivers are made into half or full width laps at the Derby doubler ready for feeding to the finisher card.

12. The Scotch feed in lower classes of waste and for lower counts of yarn, automatically transfers the cotton from breaker to finisher in a sheet of about 5 inches width.

13. The broad band feed is a more recent substitute for the Scotch feed, and makes a sheet of cotton about 16 inches width, and keeps the fibres pointing the same way for the finisher as they leave the breaker.

14. The *fancy roller* is a very old idea in the roller and clearer card, but yet found of immense value in treating cotton waste.

It is a roller of possibly 12 inches diameter placed over the doffer. The back of its teeth may just touch the teeth of the cylinder and its surface speed may be about 5 for the cylinder 4. Its object is to raise the short fibre from the cylinder teeth so that the doffer will readily strip the cylinder. Applied to both breaker and finisher cards.

15. The condenser is the most distinctive feature of all in true waste carding. It consists of arrangements for splitting up the thick cotton fleece into from twenty to forty or more separate cotton strands, which are rubbed into sufficient strength and consistency and wound as separate threads on the long condenser bobbin. There are tape condensers and ring doffer condensers. The long bobbins are taken straight to the final spinning machine, without any machines between.

The tape condenser will deal better with the finer counts, and takes the cotton in one fleece from the doffer.

The ring doffer is a favourite in Lancashire, is more simple, but is limited in degree of fineness and splits up the cotton on the doffer.

16. The roller and clearer card is often used to prepare wadding for surgical purposes, and for packing delicate articles such as jewellery. The thin fleece of cotton from the doffer is doubled upon itself until a sufficiently thick fleece of cotton waste is obtained, of the width of the doffer, and to be afterwards cut into lengths of several feet each and treated by special machinery.

17. The manifold coiler card is used for preparation yarns, and builds up four or six cans at one time, after the style of a draw-frame, and of finer counts, say about $1\frac{1}{4}$. Preparation yarns are usually from cotton waste and low-grade new cotton. They may

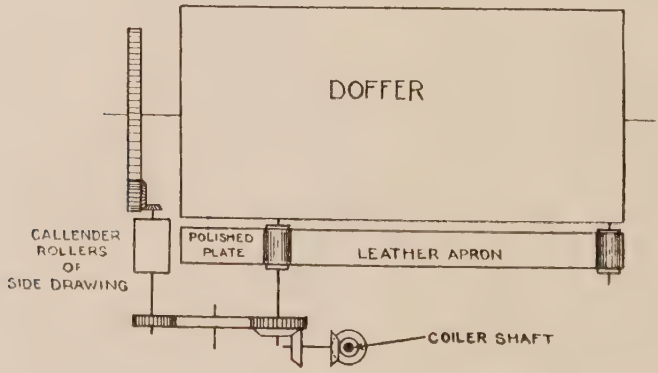


FIG. 165c.

be of finer counts, greater in strength than condensed yarns, but not nearly so valuable for very many weft purposes and are usually much cheaper. One fly-frame may be used, and the mule take large creel bobbins, and contain three pairs of draft rollers in the ordinary way.

18. Very strongly built cards are used for treating engine cleaning waste, and are half in the nature of some blow-room machinery.

19. The Nasmith comber has been much used for reclaiming long fibre from flat strips.

20. The revolving flat card is sometimes used in an ordinary spinning mill to treat the strips, but is not very suitable for cotton waste.

For cop bottom waste it is an absolute failure in the author's practical experience.

Sometimes a "fancy" is applied to a flat card, beneath the back portion of the cylinder.

21. *Draw and Fly-frames.*—Except to a very limited extent, in condenser spinning no machines whatever are used between the card and the condenser mule, or other final spinning process.

In the manifold coiler system, just one fly-frame is used, and may draft the 1 or $1\frac{1}{4}$ card strands into about $4\frac{1}{4}$ for the mule.

22. Approaching more nearly to ordinary cotton spinning and using the lowest sorts of American cotton, Indian cotton, and strips in the mixing, there are cases of preparation yarns in which the cards deliver ordinary slivers, which are put through one or two draw-frames, and then one or two fly-frames, before reaching the spinning machine. The product is cheaper than fully treated yarns and has its own market.

The Derby Doubler.—More and more used to transform cans of sliver from the breaker card into laps for the feed of the finisher

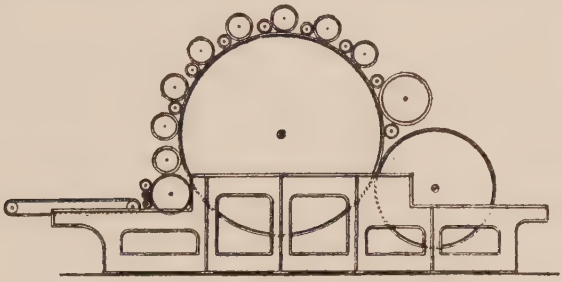


FIG. 165*d*.—Breaker roller card.

card, either narrow laps to be used two end to end for full width of card or one full width lap of itself.

Quite similar in general principles to the sliver lap machine used in fine cotton mills. Automatic knock-off motion for empty cans or broken slivers, and also for full laps. Every sliver spoon to work correctly. Uniform slivers are needed to get level good working laps. Waste excessively soft may cause lap licking at next process.

Care needed to maintain good selvedges on the laps. Brakes in good condition to get good firm laps. There must be uniform distribution of the slivers across the lap width and every detail wants watching to obtain this result. It is better to stop a few slivers than have them working on each other when heavy work is being done. Equal slivers in each half width of lap are advisable.

Uses of Waste Yarns.—Both the kinds of waste used, and the ultimate uses of the produced yarn need the utmost consideration in the various mill processes.

For belting purposes preparation yarn is often wanted on the beam: for wefts either on the cop, or else to be wound into specially hard cops on the jumbo winding frame to be unwound from the base of each cop in the shuttle. Cheese, bundle, mule cop, pirn cop, beam cheese or cone are all forms of delivery for condenser or preparation yarns.

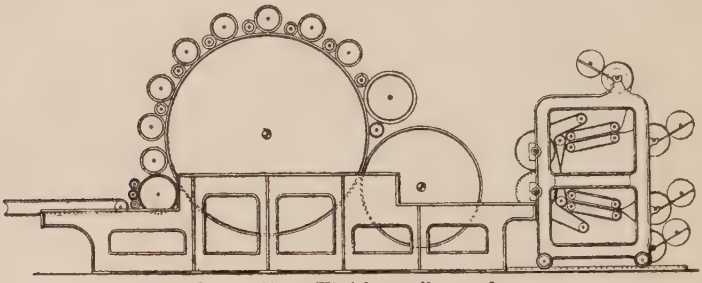


FIG. 165*e*.—Finisher roller card.

Figs. 165*d* and 165*e* show breaker and finisher roller cards for cotton waste, over the doffer in each case is the large diameter "fancy" roller.

The breaker lattice to hold two laps or to feed loose cotton.

The finisher indicates a method of making four bobbins at one time—a very unusual thing for cotton waste, one or two bobbins representing more usual practice for cotton in England.

Cotton Waste.—Notes.

The Dividing Roller.—This is usually a highly-polished wood roller coming between the ring doffer and the rubbers of a condenser card. It contains as many grooves as there are slivers or cotton ends and helps to condense the ends somewhat before treatment by the rubbers. Glass, aluminium, tin, and other materials have been tried for dividing roller construction, and it is yet a matter for research and experiment whether this could be yet improved.

The Rubbers.—These are necessary for all condenser cards, whether ring doffers or tape condensers. The rubbers should be of the best leather and kept in condition by regular treatment with castor oil. The rubbers serve as a substitute for twisting the cotton, their action being to rub the cotton ends rapidly and constantly backwards and forwards—as if an end were rubbed quickly between the palms of a person's hands—in order to produce a set or consistency in each cotton end, sufficiently for it to

draw off the long condenser bobbin at the final spinning machine without breakage.

The settings for a cotton waste card are often comparatively wide, partly owing to the often lumpy nature of some of the cotton passing through, partly owing to the fact that often some of the wire is more or less out of condition, and partly owing to the coarse character of the cotton ends often wanted, and the fact that rollers and clearers are used. For the best and finest results, however, the settings used for low grade ordinary American cotton may be approximated; say 7's to 10's for licker-in and doffer to cylinder and 10's to 12's for rollers and clearers.

Uneven Work.—In condenser spinning we depend for uniformity in finished yarn upon such items as the following: Uniformity in the cotton waste mixings; uniform feeding at the blow-room machinery; the hopper feeder at the scutcher, or in low counts and coloured cotton at the hopper feeder of the card; doubling of laps either at the scutcher or one or both cards; accurate operation of all parts of the condenser.

Faults in the Work.—Uneven ends to be checked by features such as previously specified. Side condenser ends may be either carried away by Kinsman's pipe and air current arrangement, or else wound on separate small spools or otherwise carefully watched to prevent these side ends giving unlevel work and excessive end breakage. Imperfectly rubbed ends to be checked by good setting and speeding of the rubbers and by regular castor oiling and general attention to the rubbers; "curly" ends may be caused by friction and loss of bite between the condenser bobbins and the tin drums at the final spinning process, or to bobbins not starting promptly; over-stretched ends at the condenser bobbin, due to this bobbin going slightly faster in surface speed than the doffer; neglect of proper cleaning, oiling, stripping, and grinding will reflect on the quality of the work done; defects in the rubbers, such as cracks or nicked portions, may cause crooked ends; the setting, speeding, and driving of the fancy roller must always be carefully attended to.

In condenser spinning the work centres much more around the carding engines than in ordinary spinning. For low-class work blank under casings may be used on the breakers, and for better sorts of work ribbed under casings. Many people prefer to omit under casings from the condenser cards so that there shall be no portions of fly picking off and spoiling certain condenser ends. The best condenser spinners often sell their condenser card fly to spinners of the lower classes and counts.

Assuming the doffer to be driven from the licker-in and the condenser from the cylinder there is here a chance for all ends being broken when a belt breaks.

Chain driving for rollers, belt driving for clearers, and rope

driving for fancy roller and doffer comb. If possible the doffer comb wants even more attention on a condenser card than in ordinary spinning.

An American System of Dealing with "Hard" Cotton Waste.

(1) Cop-waste; (2) winder's waste; (3) slasher, sized spooler; (4) coloured threads, which consist largely of coloured slasher and coloured spooler; and (5) weaver's waste.

"Certain lower grades of desired qualities selected to make a mix are opened, and the stuff from one is spread out on tables, 4 feet × 10 feet, with wire mesh top. Women work it over deftly and pull it towards them in such a manner as to drop dust, lint, and all variety of small foreign particles through the mesh, at the same time picking out needles, large metal splinters, and other extraneous objects, and pushing the cleaned waste into hampers, 3 feet × 4 feet × 5 feet, mounted on castors. Where not of a uniform character, the various kinds are sorted and graded into the various hampers. As each hamper is filled it is trundled to bins in the stock-room, and the material is used in the mix in the quantity prescribed.

"In the mix room, of large size, a floor space is cleared for mixing the several waste ingredients called for. There the bales are opened and spread out by hand one after another, together with the specified screened stuffs, and this process is repeated, layer on layer, until the required weight has been laid.

"The mass is yet only incompletely mixed, and an additional hand process is resorted to, to gain greater uniformity. Standing on all sides of the spread-out mass the mix-gang pulls out handfuls of waste, at the same time cutting with a long knife any lengths of threads over 18 inches to 24 inches in length. This is then thrown behind them on a cleared space. It is next carried over to another set of large-size screening tables, where it is pulled across the mesh, inspected a second time, and re-picked, removing any remaining extraneous material, every movement serving to mix and standardise it further.

"The mixed waste is, however, at this stage, rather lumpy and unhomogeneous, and still not thoroughly assimilated. It is, therefore, necessary to resort to a third process, known as machining.

"In this operation the re-screened waste mixture is dropped down a chute to the machining-room. This department contains ten picker machines with an individual capacity of 1,000 lb. per hour, each belt driven from a line shaft driven by one 75 h.p. and two 50 h.p. motors at 1,500 r.p.m. In these picker or carding machines the waste is fed against a rapidly rotating

cylinder covered with curved teeth pointed backward from the direction of motion so as to slide over the mass with a stroking action that opens the ply and combs out the material. These cylindrical rollers are encased to hold the waste closely against the teeth. The waste as it is combed is carried over the cylinder and comes away from it on the opposite side as a loose mat. In this form it is wrapped around rollers by the machine tender as it emerges from the mill, and is subsequently slid out of the roll at the first opportunity and later returned to receive another 'lap.'

"Upon the laps reaching the baling department each one is inspected and weighed before being dropped into the baler, and exact weights are compressed equivalent to 94 per cent. of the gross bale weight in a 100-lb. bale, and allowing 6 per cent. for tare, consisting of burlap covering and steel bands. Standard bales are 25, 50, 100, 250, 500-lb. sizes, and also in miniature packages, 5 and 10 lb., for garage work. Standardisation and uniformity are thus obtained in the working quality of the waste, in its net weight and in the tare."

Card Condenser.

The cotton is taken from the finisher card by a condenser, which divides the doffer web into a number of narrow strips, which are rubbed into strands and wound side by side on the long condenser bobbin. A condenser arrangement is shown in Fig. 167, but is not really so complicated as it appears at first sight.

The number of divisions or strands varies greatly according to the counts to be spun.

It is not often that drawing rollers are used in waste spinning, the usual practice being to take the long condenser bobbins and place them behind the waste spinning mule, in which only one pair of rollers are used. The only "draft," therefore, is between the spindle points and these rollers, and it seldom exceeds more than about 40 to 50 inches pulled into about 64 inches or more.

Diagrammatic views of the breaker and finisher waste cards as made by Hetheringtons are shown in Figs. 165*d* and 165*e* given previously.

The Fancy Roller—The "fancy" roller is a distinctive feature of both breaker and finisher cotton waste cards.

The cotton waste is almost always so short, soft, and fluffy, that it would very inefficiently be transferred from cylinder to doffer unless helped in some way not found necessary on ordinary cotton cards, although even in those cases the transferring action is far from being a perfect one. On a waste card the "fancy" is a roller placed against the cylinder above the doffer. The "fancy" is wire covered with rather long bent wire whose backs brush more or less

against the teeth of the "fancy" in order to entice the cotton fibres up for the doffer teeth to take hold thereof. 9 to 12 inches diameter, *contact* surfaces revolving the same way, the "fancy" roller needs a high number of revolutions per minute in order to exceed in surface speed the cylinder by possibly 8 to 12 per cent.

In some cases the "fancy" teeth are set to very slightly penetrate the cylinder teeth and in other cases to barely touch. Correct setting, wiring, and speeding of the "fancy" are needed to prevent "nep." Very large driving and very small driven pulleys on a compound system are used to get up a sufficiently high "fancy" speed from a cylinder making from 70 to 90 r.p.m. at 50 inches diameter, as against twice that speed on a revolving flat card for ordinary spinning.

Scotch Feed (see Fig. 170*a* further on).

This is extensively used in Bolton and other districts for low counts of waste yarns 1's to 4's cotton counts.

Automatically transfers the cotton from breaker to finisher cards by taking the 3½ to 5-inch cotton ribbon from breaker front, upwards and overhead, then down again to the back of the finisher, and automatically spreads the cotton on the finisher feed lattice. Very much used in some Continental centres.

The "soho" or "broad" band feed is an improvement on the "Scotch" feed by working on a sheet or ribbon of cotton very much wider, and feeding "straight fibre" instead of crossing the cotton at right angles between breaker and finisher.

A difficulty in the automatic cross feeders is that of maintaining absolute and accurate driving of both breaker and finisher.

Uneven work may be affected by the operation of the hopper feeder to cards, or by different characters of waste used, or by the feed bevels of breaker and finisher differing.

It is no easy task to maintain exact accuracy of laying the cotton uniformly on the feed lattice of the finisher by the Scotch feed.

The utter absence of the "doubling" principle in waste mills worked on the Scotch feed principle makes it difficult to maintain uniform work.

Fig. 166 shows both a single and a double bobbin condenser. No. 1 shows a two-lap feed, two sets of rubbing leathers at RR, two dividing rollers at DR, two condenser bobbins at CB.

No. 2 shows one pair of rubbers R^1.

Ring doffers in each case.

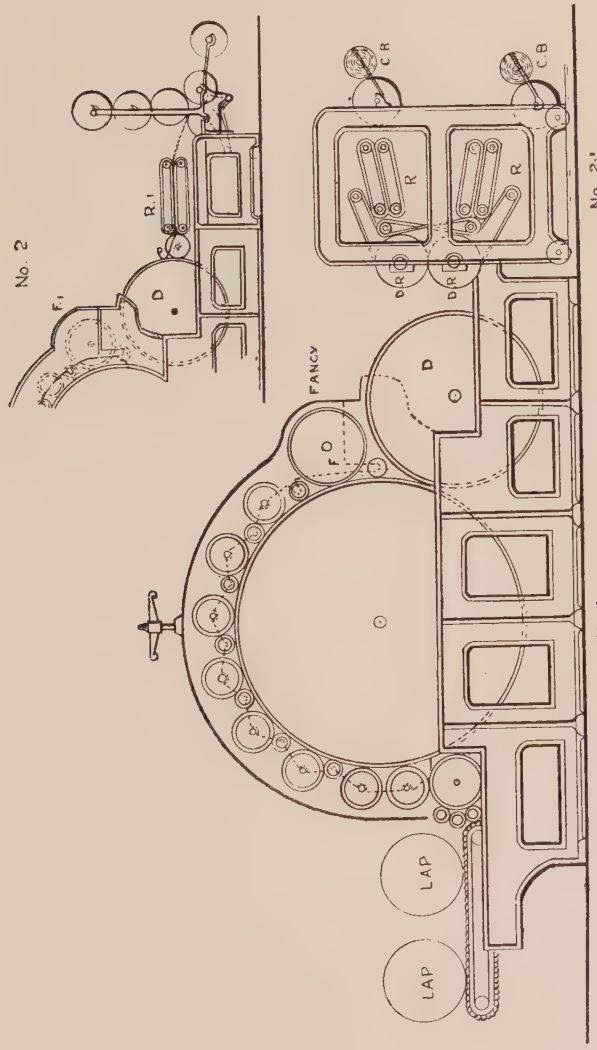


FIG. 166.

Condenser Strand Breakage.

No machine in an ordinary cotton-spinning mill gives less trouble, requires less attention, and is less subject to breakage of the front sliver or cotton strand, than does the carding engine.

Per contra it may almost be said that the condenser cotton strands want as much attention as at any machine in proportion to number.

Breakage of cotton strands is often serious, heat and moisture of rooms affecting this problem. Possible causes are as follows: Faults in back laps, "humbug" or "fancy" rollers more or less wrong in some way, too much tension between doffer and condenser bobbin, wire of doffer or cylinder broken, bent or wrongly set, doffer to cylinder or doffer comb to doffer not properly adjusted, doffer comb not sharp enough or not running quickly enough, rubbers not properly treated with castor oil, or olive oil, stickiness of dividing roller, rubbing leathers not of correct tension. In tape condensers the tapes may become worn down from about $\frac{5}{8}$-inch width to $\frac{1}{2}$ inch.

The Ring Doffer.

In a ring doffer for thirty ends there may be thirty wire fille rings of $1\frac{1}{8}$ inch or so wide, with a leather $\frac{1}{4}$-inch wide ring between each pair of fillets (see Fig. 159).

The cotton divides out and follows the wire fillet.

The fillet on either edge of doffer often gives a more or less defective cotton strand although frequently made wider than the other fillets. It is within our own personal experience that bad spinning often results from these side ends.

Kinsman's side-end motion is now applied to many ring doffer condensers, and the writer has seen it working to advantage in Bolton. At each side of the doffer and dividing roller are placed vertical tubes which are carried downwards and coupled to a main tube or pipe arrangement. A fan arrangement draws the side end waste from many cards to a convenient receptacle for using again.

Under Casings.—In roller and clearer cards for cotton waste custom is not so fixed in regard to cylinder under casings as in ordinary flat cards for ordinary cotton spinning.

For low grades and low counts of condenser yarns blank under casings are sometimes used to keep all in.

On the other extreme for the finer and better classes of condenser cotton yarns many cards are at work without any under casing at all, as this gives a cleaner and better yarn, and reduces breakage of ends at the condenser. The extra fly thus made is used over again for lower grades and counts of cotton waste yarns or for wadding.

Ordinary under casings are used if required, and especially when there is no condenser on the card.

Ring Doffers.—Whatever may be said of the ring doffer it remains the favourite method in such important waste spinning and weaving districts as Bury, as distinct from one or other form of

tape condenser, which, however, in its simplest form appears to gain adherents for some kinds of work.

The division of the cylinder web into separate strands by having a smooth leather ring $\frac{1}{4}$ to $\frac{5}{16}$-inch wide between every ring fillet of $1\frac{1}{8}$ to $1\frac{3}{8}$-inch width, requires best attention to get cotton strands uniform in counts over full width of doffer. The feed of cotton to finisher is first check on uniformity, whether it be Scotch feed, broad band feed, or Derby doubler feed.

Taker-in without broken teeth, "humbug" roller beneath taker-in properly set and clothed, "fancy" doing its work well, the rubbers giving satisfactory rubbing action, cotton strands not crossing to adjacent ones, correct tension between front bobbin drum and doffer; all need close care.

There is usually a change wheel between doffer and bobbin drum to get the best tension—neither too much nor too little at this point. The writer has often seen much breaking of cotton ends at this point through the front friction drum going a little too fast in relation to the doffer.

Side shaft bevels and doffer production wheels are much the same as on ordinary cards, but such changes are complicated in effects when breaker and finisher cards are automatically connected; worse still if the breaker card has a hopper feeder.

Finisher cards supplied from Derby doubler always permitted a doubling of two into one cotton sheet to obtain uniform work. Either two full width laps or four half width, two of which end to end equal full width of card.

Condensers do not twist cotton, but rub the strands backwards and forwards as if done between the hands.

The Leather Tape Condenser.

Much advocated by some machine makers of recent years, tape condensers are much used on the Continent and are now to be found in a good number of English mills. The difference comes in between the main cylinder and the rubbers, and consists mainly in the character of the doffer and the apparatus which collects and divides out the cotton from the doffer. A tape condenser appears complicated at first, but is really simple (see Fig. 167).

In the case of the ring doffer, the doffer itself does the actual dividing or splitting up of the cotton into strands, such splitting being afterwards perfected by the dividing roller. The doffer in the tape condenser is wire clothed continuously by spirally wound fillet as in ordinary carding, but using coarser counts of wire. The delivery of the thick web of cotton from the doffer in a continuous sheet enables a subsequent splitting up into two to four or more separate condenser bobbins all making at the same time and

is good for production. Narrow, endless leather bands or tapes take the cotton from the doffer and are so set and passed over grooved calender rollers, that the leather in the groove of the upper roller is opposite the metal in the lower roller and vice versa. The cotton follows the leather in each case in preference to the metal so that two sets of strands are formed. For cotton a two-bobbin tape condenser appears very suitable, but single bobbins are much used for the lowest counts.

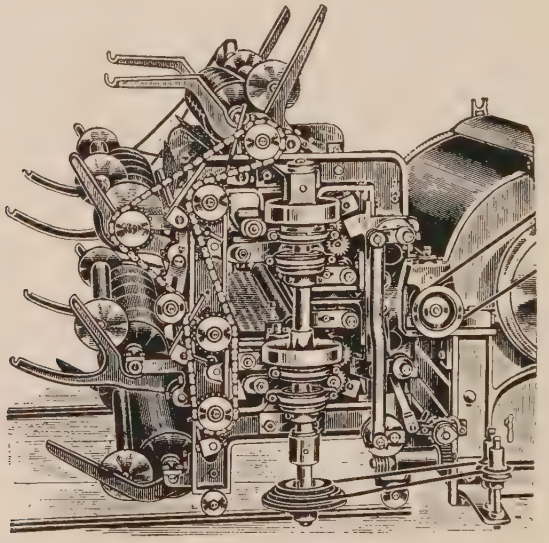


Fig. 167.—Cams of a tape condenser.

Treatment of Card Strips.

In the average spinning mill card strips constitute a very considerable item in the amount of usable waste. Very frequently the strips contain a good percentage of fibre sufficiently long and good for the ordinary spinning purposes of the mill if they can only be sorted out of the mass without much trouble or inconvenience. Much of the strip is sold to waste dealers. In some cases one of the ordinary flat cards is set aside at the spinning mill for treating the strips, and stripping is done possibly five times per day instead of three owing to the cylinder becoming quickly choked up with short fibre. Also the flats may be run a little more quickly.

The application of a "fancy roller" below the cylinder near the taker-in would in such cases remove a good deal of the evil of the cylinder choking, and the "fancy" need scarcely touch the cylinder.

A roller and clearer card fitted with a "fancy" and side drawing

would treat the strips with scarcely any trouble, but it needs a grinding frame for the rollers and clearers.

The Nasmith or other comber is sometimes adapted specially for the recovery of good fibre from the strips, and perhaps more so for Egyptian cotton.

This is the most ambitious and most expensive method of treating card strips, and for this reason is not in favour with a good many spinners.

In a complete installation of this kind the card strips are passed through such of the blow-room machinery as may be deemed advisable, such as simple opener or scutcher.

In the ordinary way the laps are put through the card and made into slivers. In the ordinary way the slivers may be levelled in one head of drawing, and then made into narrow laps at the sliver lap machine.

Or instead, the more modern method of ribbon machine and sliver lap machine may be adopted to prepare narrow laps for the comber. Finally, the prepared strips are treated by the comber and put into slivers for the usual draw-frames.

The extra parallel order of the combed fibres helps to give at least as strong a yarn as the carded slivers and mixing is readily done at the usual draw-frames.

Strips are not good at cleaning, and require considerable treatment to get them free from impurities.

It has been stated that 60 per cent. of good usable stock may be recovered in this manner from the original weight of strips. At draw-frame one sliver of strip put with five slivers of carded cotton.

Condenser Drafting Machine, made by Messrs. Tweedales & Smalley, Castleton, near Manchester.

		Diameter.	Revolutions Per Minute.	Surface Speed Per Minute.
B	Fluted feed roller	$1\frac{3}{4}$ in.	3·66 6·64 16·04	16 change wheel = 20·16 in. 29 ,, ,, = 36·52 ,, 70 ,, ,, = 88·21 ,,
C	Feed roller weight, 8 lb. . . .	—	—	—
D	Cylinder . .	10 in. covered	380	11,938 inches.
E	"Fancy" roller .	$6\frac{1}{4}$,, ,,	748	14,687 ,,
F	Clearer ,, .	$2\frac{5}{4}$,, ,,	34·37	297 ,,
G	Doffer . . .	$5\frac{3}{4}$,, ,,	26·37	476 ,,
H	,, comb .	—	1400 strokes	—
J	Rubbing rollers .	—	—	463 ,,

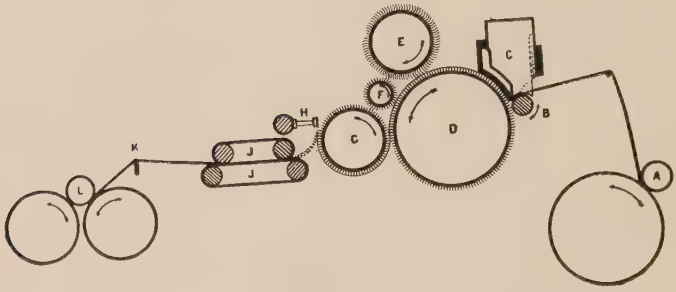


FIG. 168.

A = condenser bobbins fed to drafting machine.
L = „ „ delivered by drafting machine.

This is a machine for enabling much finer counts of yarn to be spun.

It is one of the most recent machines for treating cotton waste.

Approximate Productions.

Counts spun on mule	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
„ on drafting machine	—	—	—	2⅔	3⅓	4	4⅔	5⅓	6	6⅔	7⅓	8	8⅔	9⅓	10	10⅔
Counts on finisher cards	¾	1½	2	½	½	¾	¾	¾	1	1	1	1	1	1	1	1
Production per 10 hours of card with condenser for 18 ends, in lb.	210	140	105	210	210	210	210	210	210	210	210	210	210	210	210	210
Revolutions per minute of doffer, 26 in. diameter	5¼	7	7	3½	3½	5¼	5	5¼	7	7	7	7	7	7	7	7
Production per 10 hours of drafting machine with 36 ends equal to 6 r.p.m. of a doffer 26 in. diameter, in lb.	—	—	—	135	108	90	77	67	60	54	49	45	41	38	36	34
No. of mule spindles (1⅞ in. gauge) per card	84	84	84	224	294	362	392	470	522	588	628	672	726	784	856	940

Self-acting Oiler for Condenser Rubbers.

Instead of running the card bare every second or third night so as to apply castor oil to the rubbing leathers by hand, it is possible to use automatic oilers.

The ordinary method of hand oiling is done at night to give the rubbers every chance to dry up before next morning.

The rubbers are expensive to change, but will give bad work if out of order or allowed to become too dry.

In the automatic oiler tubes of 1½ inch diameter may be passed between the rubbers and supported in proper bearings. The oil circulates through the tubes when required, and passes through small holes in the tubes and upon the leathers. Proper boxes for holding the oil are arranged and ingenious means provided for stopping the oil when not required and for finely distributing the oil to the rubbers as required.

The Cup or Pirn Building Motion for Cops.

In the cotton waste trade this principle or method of building cops is somewhat extensively utilised. It is to be found on the can spinning frame, the Chapon spinning frame, and on the jumbo winding frame for winding condenser yarn into very hard weft cops for the shuttle. It is possible to do this without giving any bobbin or tube to the loom so as to get the maximum amount of

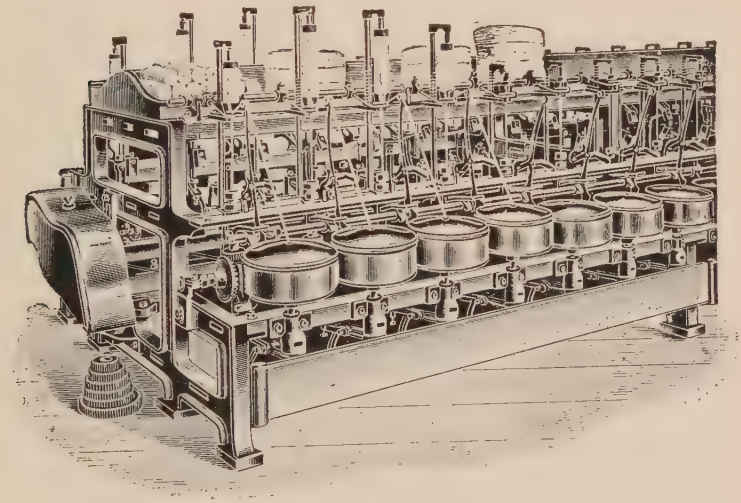


Fig. 169.—The can spinning frame.

yarn in the loom shuttle—a very valuable feature. The cop is built in cone cup with a bobbin braid and an inner spindle. As the cop builds up it is forced upwards by its own increasing diameter until sufficient length is obtained. The yarn may be afterwards unwound from the base of the cop. The cops are unexcelled for readying, due to the quick rate of winding-on traverse.

Methods of Feeding Waste Cards.

In some cases the material may be fed in loose state behind the breaker card, while in others two laps from the scutcher may be placed behind the breaker. To feed the finisher card there are mainly three methods. (1) The slivers from the breakers are made into laps for the finisher by the Derby doubler. (2) In the second case the Scotch or cross feed takes the cotton in the form of a ribbon from the breaker and spreads across the back of the finisher as it were in layers so as to form a continuous sheet. (3) The broad band feed has a broader cotton sheet than the Scotch feed and does not turn the fibres round.

The fibres are crossed and mixed a great deal in relation to the card teeth, as it is not desired to make the fibres parallel. The Scotch or cross feed probably presents the fibres in a more crossed manner to the finisher card teeth than does the sliver lap machine.

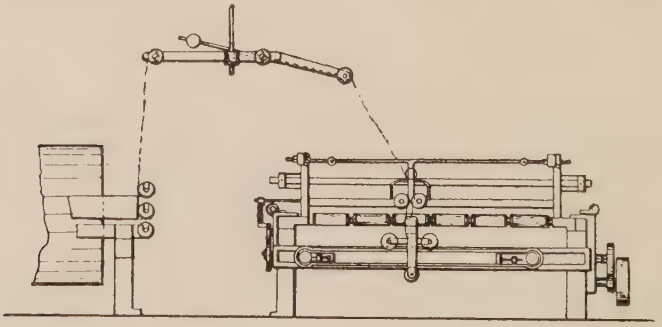


FIG. 170*a*.—Scotch feed.

The condenser is an apparatus placed at the delivery end of the finisher card, by which the web or fleece is divided into individual strands or ends, which are then wound on the condenser bobbins ready for the creel of the mule.

Various methods of feeding are shown diagrammatically in Figs. 170*b* and 170*c*.

Fig. 170*b*, at left hand, shows Bank's feed; Fig. 170*c*, at the left hand, shows the lap drum; and Fig. 170*a* shows the Scotch or cross feed method of conveying the cotton from breaker to finisher.

There are two chief parts: (1) The feed of the breaker card; (2) the feed of the finisher card for cotton waste. There are alternative methods in each case. (1) The breaker card receives the cotton from the blow-room, and it is a very common practice to place two full width laps from the scutcher on a feed lattice at the card so as to obtain more uniform work from the card. Sometimes

loose cotton from the blow-room is carefully spread upon the feed lattice of the breaker card, while a still more modern practice to some extent adopted is to place the loose cotton into a hopper feeder attached to the card. (2) Coming now to the finisher, we have the Scotch feed method, the four lap method, and the lattice feeder. In the Scotch feed and Scotch roper system the cotton

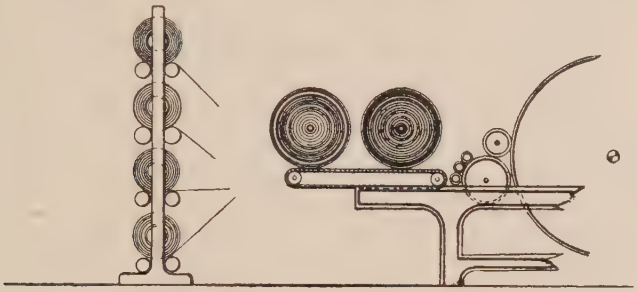


Fig. 170*b*.

waste is delivered from the breaker card in the form of a condensed ribbon, possibly 4 inches wide, which is drawn upwards, run from breaker to finisher either sideways or forwards as required, and is then spread by travelling rollers across the feed lattice of the finisher. In this method the fibres are turned round at right angles to their previous position, and are very much crossed one with another.

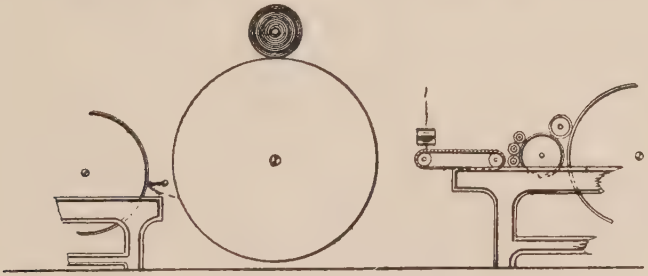


Fig. 170*c*.

The lattice feeder is also a continuous transit from breaker to finisher in which very much wider ribbons or sheets of cotton waste are formed, and are then spread across the feed lattice of the finisher, the work being done in such a manner that the fibres are kept in same order as they leave the breaker.

For the finer counts of waste spun yarns the Derby doubler is often preferred, and in this case the cotton from the breaker is

formed into the well-known slivers which are converted into laps half width of the card at the Derby doubler. Afterwards two pairs of these laps are fed to the finisher, arranged end to end as if there were only two laps. Cases exist in which two full width laps are used instead of four half width laps.

The Bobbin and Fly-Frame for Spinning Waste Yarns.

This method is utilised more or less in various ways in connection with cotton waste yarns. If the ends break much from any cause, the work of the operative and the loss in production are very considerable.

1. It is used as a condenser spinning frame for both twist and weft sponge cloth yarns for re-washing cloths. Only one line of top and bottom rollers, the machine in this case only twisting and winding-on without any drafting.

2. It may be used as a spinning machine for coarse yarns of little twist per inch, from large size creel bobbins and three pairs of draft rollers. Yarns to be wound upon cheeses for warp, or upon jumbo cops for weft, and to come off either the end or side of bobbin as desired.

3. Sometimes it is used as a doubling frame for twisting two single soft ends together such as for wefts in leno sponge cloths. Two ends of 100 or 120 yards per oz. may be twisted together to obtain a 50 yard per oz., or 60 yard yarn. Re-wound on a jumbo winding frame into large closely built cops for the shuttle. Shuttle with elastic or metal lid to hold cop down. Yarn to come from base of cop. The Chapon and can spinner have the advantage of making such cops at the same time as spinning.

Two Kinds of Cotton Waste Mule.

Broadly speaking, cotton waste mules may be primarily divided into two principal classes—condenser mules and mules for spinning on the preparation system. The condenser system of spinning cotton waste is the true one, and is far and away the more used of the two, being constantly increasing in use, whereas the preparation system of spinning is apparently on the decline. Condenser mules for spinning cotton waste may be sub-divided into two great classes —those in which the woollen type of headstock is used, and those in which the cotton headstock has been taken as a basis. The latter is the more modern system, and is much more used than the other type and continually gains in favour. The most distinctive features are the drafting of the cotton entirely by the carriage without using drawing rollers at all, combined with special mechanism for imparting three different speeds to the spindles during each

outward traverse. The roving may be delivered from the rollers at a uniform rate throughout the draw, but at only from a half to two-thirds the rate of the carriage movement—thus depending for draft upon carriage "gain" as distinct from the woollen system of depending upon "ratch" or second stretch. The rollers consist often of one top roller line working upon and between two lines of bottom rollers, or possibly one line each of top and bottom rollers. The carriage speed is uniform, but the spindles only have a very slow speed during the first few inches of the outward travel. The movement of a belt then causes an accelerated speed to be given to the spindles, and then possibly 18 inches or so before the carriage gets out the belt is moved upon another pulley, and a larger rim pulley gives the third or maximum spindle speed until twisting is completed. The low first and second spindle speeds keep the twist down to a minimum, thus keeping the yarn soft and permitting the large amount of carriage draft without breaking the threads.

In cotton waste mules on the woollen mule headstock system special motions are often employed, such as a "jacking-up motion," which moves the carriage in during twisting at the head; slubbing motion for regulating the amount of cotton delivered from the rollers each stretch. The creel of a condenser mule consists chiefly of long tin drums, upon which the long condenser bobbins are laid lengthwise and are unwound by friction.

In spinning 6's or 7's on cotton headstock system from a fair class of waste, three-speed mule the first speed might be about 800 r.p.m., the second speed 1,500, and the third or final speed 2,500.

The Condenser Cotton Waste Mule.

A condenser cotton waste mule differs fundamentally from an ordinary cotton spinning mule, in having no draft rollers whatever, depending upon the principle of carriage draft entirely for making the cotton strands finer.

Long condenser bobbins direct from the finisher condenser card are placed on surface drums and driven therefrom by frictional contact so as to maintain a uniform unwinding speed for all diameters of bobbin.

Each bobbin contains a good number of individual strands—ranging from eighteen or twenty for sponge cloth yarns up to thirty or thirty-six or so for yarns of 7's to 10's cotton counts for flannelettes, shirtings, carriage rugs, etc.

The draft in the condenser mule is limited to something less than 1 drawn to 2, and 4's drawn to 7's counts is not often exceeded.

The woollen type of headstock was formerly much favoured for cotton waste condenser mules, and is yet used in some instances.

It may be distinguished by such features as variable scrolls or

fusees for drawing the carriage out at variable speeds, slubbing motions for stopping the delivery of cotton after the carriage has moved more than half way out, and drafting the cotton on the ratching principle, instead of the "gain" principle.

Cotton Headstock.

Of recent years nearly all the makers have developed the headstocks and workings of the condenser cotton waste mule, more upon the lines of the headstocks of mules for ordinary cotton spinning, and these headstocks have become the favourite type for cotton waste.

The carriage in these cases is drawn out at a practically uniform speed all the way, the drafting is done on the principle of "gain" of carriage instead of "ratching," the ordinary long back shaft is used, stretch lengths of about 64 inches are often preferred, as against 70 inches or more in the woollen type of headstock.

Arrangements are applied for giving three distinct and fully controlled speeds to the spindles during any one draw, and this three-speed motion may be applied to woollen mules if so desired.

Carriage Retarding Motion.—The first small portion of yarn from the rollers every time the carriage starts out from the beam, is sometimes too hard for the carriage draft of a condenser mule. In such cases it is possible to have a back shaft box arrangement which operates on the well-known anti-snarling arrangement of the ordinary roller box. Wide spaces are used on the internal disc keyed on the back shaft. A spring arrangement draws the loose half of box away from the driving snugs when the box opens. The amount of the draw-away can be easily regulated to requirements. The effect is to delay the start out of carriage until after the rollers have started and thus to soften and ease the yarn.

N.B. — Preparation yarns are sometimes used for weaving towels, tapes, lamp-wicks, hose-piping, braids, brace webs, and woven belting.

Bump Counts.

For the very lowest counts of cotton waste yarns the counts are often taken at so many yards per ounce.

For example; instead of saying counts $1\frac{1}{2}$, the yarn may be quoted at 75 yards per oz.

Thus $840 \text{ yards} \times 1\frac{1}{2} = 1200$ yards per lb.

and $1200 \div 16 = 75$,, ,, oz.

So-called bump yarns because of the weft requiring very heavy beating up in some cloths, and formerly much done on hand looms.

The leather rubbers of the condenser card may be treated with castor-oil every second or third night, to maintain a good rubbing

action on the cotton strands. Automatic oilers are used in some cases.

Cone Driving of Condenser Mule.

A good many of the mechanisms of a condenser mule with cotton headstock resemble those for ordinary spinning ; such as copping, backing-off, drawing-in and drawing-out of carriage, faller locking and unlocking.

In cotton condenser spinning it has always been found that a low initial spindle speed must be obtained to permit of the large amount of carriage draft required. As before stated the most successful modern system—now made by several firms—consists in adapting the cotton-spinning headstock chiefly by dropping the draft gearing, making a creel for condenser bobbins, and applying a 3-spindle speed motion.

Many years ago a Bury firm obtained the variation in spindle speed by cone driving, and this drive has done very well in a number of waste spinning mills. To start the spindles at the minimum speed, gradually and continuously increase the speed during all the run out of carriage appears quite sound in principle, but belts, bands, and cones are always more likely to develop trouble than the more positive drive of the modern 3-speed mule. In both cases the roller delivery and the carriage travel remain constant all the way out. The cone belt in this case needs to be moved along the full usable length of cones during each outward run of carriage and back again during each run in. About a four to one variation in speed could be obtained by using the full value of the cones. For some sorts of work the spindle revolutions might vary from 500 to 1,700 rate of revolutions per minute, the rate progressively increasing all the time, as distinct from the specific three quantities of the three-speed motion.

Quadruple Coiler.—The quadruple coiler card is shown in Fig. 164.

This quadruple coiler system is attached to a roller and clearer card working on the "preparation" system.

The fleece of cotton from the doffer is split up into four parts, and four cans of fine sliver are formed at one time perhaps half hank. Placed behind the slubber, made into counts of $1\frac{1}{2}$ to $2\frac{1}{4}$, and the bobbins taken directly to a mule having three lines of rollers.

Can Spinning Frame.—As shown in Figs. 169 and 171*a*, the can spinner is used only for the very coarsest wefts from low classes of waste.

Slivers from the condenser bobbins are placed 3 inches deep in the shallow cans. The cotton is drawn upwards through a central aperture in the can, and upon the weft cops. Cops built upside down on the pirn or jumbo winding principle.

A distinctive feature is the "up twisting" one has heard so much about in a recently adopted winding frame. Each can is rotated to twist the cotton at least sufficiently for purposes required.

Cops made of almost any diameter and length required, afterwards unwound from the inside to be used for some sponge cloths and other very coarse goods.

The reader is referred back to page 665, Fig. 161, for an illustration of the soap-water machine.

The soap-water is automatically kept at the required height so that roller A picks up more than sufficient water, and surplus water is swept off by the brush B. There is a lattice which carries the soaped cotton along to the mixing, in which it should stand

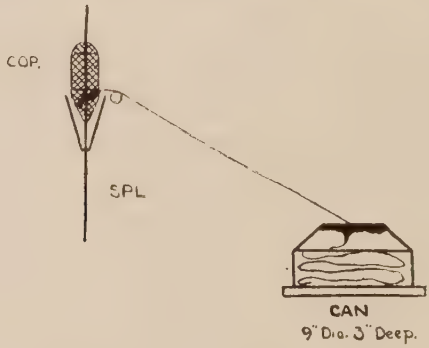


FIG. 171*a*.

from twelve to twenty-four hours. The present writer has known a waste mixing to get very warm inside after being well damped with soap water and standing four or five days before using.

Patent Three-Speed Motion for Special Waste Mules (Fig. 172).

(Messrs. Asa Lees & Co.)

In order to obtain the three speeds the ordinary cross taking-in shaft is made into an auxiliary rim shaft by mounting on it a pair of fast and loose pulleys. The taking-in pulley and bevel with the backing-off pinion work loose on this shaft and operate the taking-in and backing-off in the usual way.

The auxiliary rim shaft also drives the carriage throughout its outward run by means of the usual rim pinion, front spindle bevels, and back shaft gearing.

The three different speeds are brought into operation as follows:—

1. The fast pulley A on the auxiliary rim shaft, through the 33's wheels drives the roller clutch B working inside the fast pulley E. The driving strap being held on the loose pulley F, by the latch lever J holding the cam strap lever H, the roller clutch is free to drive the fast pulley E, and through it the small rim M, fixed to the other end of the shaft, which drives the spindles at the slowest or first speed.

2. After the carriage has traversed about 18 inches of its outward run the driving strap is moved forward from its loose pulley F to the fast pulley E, by the tumbler lever L coming in contact with the small incline on the lever K, thus lifting the latch lever J, and allowing the cam strap lever H to move by the tension of the spring N. As the rim shaft runs quicker than the auxiliary rim-shaft, the fast pulley E now over-runs the roller clutch B, thus driving the small rim M at an increased speed, and the spindles at the middle or second speed.

3. As the carriage comes near the completion of its outward run, the tumbler Q coming in contact with the incline on the long lever R, lifts the cam strap lever H by means of the connecting rod T and the lever U, and thus moves the driving strap back to the other fast pulley G, which is keyed on the long sleeve O, which carries the large rim P. In this position the twist motion latch S, and while it is so held, the large rim pulley drives the spindles at the third or highest speed.

The two inclines on levers K and R are adjustable, so that the quicker speeds can be brought into operation at different times to suit the material dealt with. On the completion of the outward run of the carriage, the strap on the auxiliary rim shaft is drawn on to the loose strap pulley A1, by the strap relieving motion.

After the twist has been completed at the head, the twist motion latch S is released by the twist finger in the carriage square, and the driving strap moves into its first position on the loose pulley F, being held in that position by the first speed latch J.

The Taylor-Lang three-speed motion is shown in the author's "Cotton Waste" treatise.

The *Chapon* is a somewhat important spinning machine which makes somewhat finer numbers, and may subject the condenser bobbins to a slight roller draft (see Fig. 173*a* for cotton passage).

Both this and the can spinner wind and build the cops on the principle of the pirn winding frame. The can frame may be more for cleaning cloth yarn and the Chapon to produce wefts for quiltings and cotton blankets.

An ordinary fly-frame may be adapted to prepare waste yarns either on the preparation system from slubbing bobbins and with

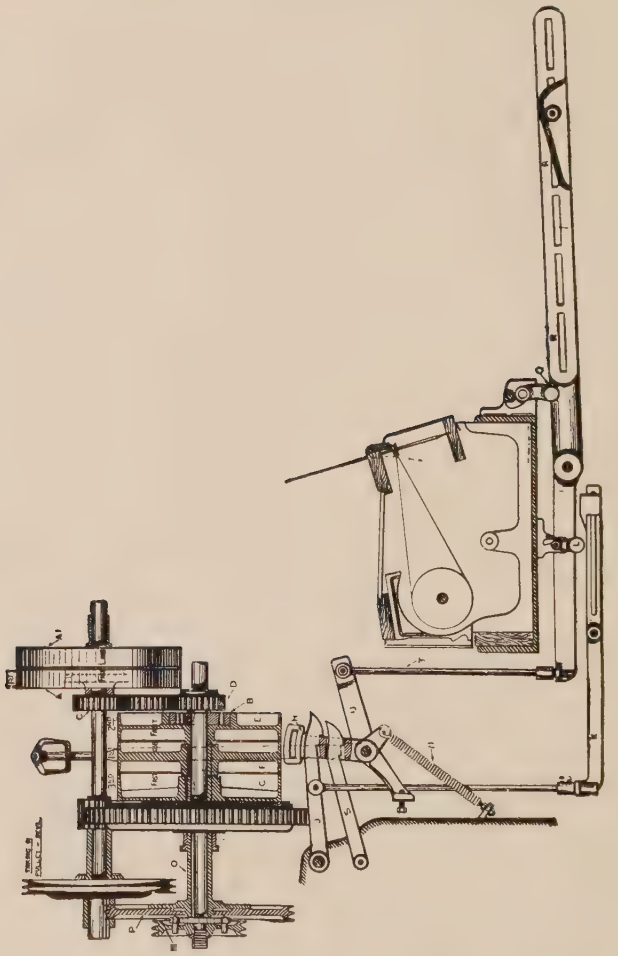


FIG. 172.

References to Diagram.

A Fast pulley on auxiliary rim shaft.
A1 Loose pulley on auxiliary rim shaft.
B Roller clutch on rim shaft.
C 33's wheel on fast pulley A.
D 33's wheel on boss of roller clutch.
E Fast pulley keyed on rim shaft.
F Loose pulley on rim shaft.
G Fast pulley keyed on long sleeve.
H Cam strap lever.
J First speed latch.
K First speed incline lever.
L First speed tumbler lever on carriage.
M Small rim for first and second speeds.
N Spring for cam strap lever.
O Long sleeve for fast pulley G.
P Large rim for third or quick speed.
Q Third speed tumbler lever on carriage.
R Long lever for third speed.
S Twist motion latch.
T Connecting rod.
U Lever on strap guide shaft.

the aid of drawing rollers, or to make yarns from condenser bobbins without using draft rollers. Given good back stuff, and when the yarn requires reeling, a great deal of yarn may be put on one bobbin.

The false twisting machine has received some attention of recent years. From condenser bobbins the cotton is drafted slightly between two pairs of rollers several inches apart, and between these rollers a false or temporary twisting effect is produced which prevents the cotton strands from breaking.

Afterwards the yarn is placed upon ordinary ring-frame bobbins of large size.

The condenser cotton is taken through a pair of feed rollers which have a surface speed practically equal to that of the condenser surface drums, and is then passed through a twisting tube to what may be termed the drawing rollers. Leaving these rollers

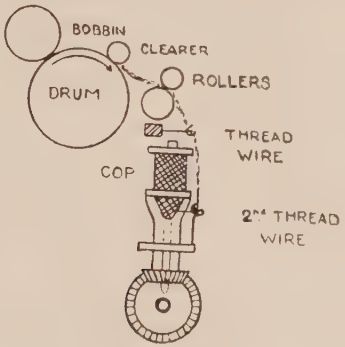


FIG. 173.

each thread passes through a traveller and upon the ring in the usual way.

Special attention may be now drawn to the most distinctive feature of the machine.

One pair of rollers is placed reasonably close to the condenser bobbins, and a second pair a little distance above the thread wire and lappet. There is a moderate amount of draft between these two pairs of rollers—one pair being distinctly higher up than the other, and some distance away, so that the draft differs entirely from established ideas of roller draft, and practically imitates the principle of "carriage gain" on the self-actor mule. The false twisting principle is introduced to permit of this gain or draft.

Between the two pairs of rollers, and practically as close as possible to the lower pair, a vertical twisting tube is placed, containing a spindle wharve and driven round in the usual way by a

spindle band operated from a spindle band passing round an extra tin roller placed well above the ordinary one for the ordinary ring-spindle. The roving passes down the twisting tube whose revolution imparts a temporary or false twist to the yarn. The yarn is agitated by two pegs on the top of the tube to imitate the slipping of the yarn over the spindle point in a mule spindle. The use of this false or temporary twist strengthens the yarn and enables it to withstand the drafting or gaining action taking place between the two pairs of rollers. The twist is only temporary because the yarn is held firmly at each end, whilst the central tube is twisting, whereas to get a proper twisting effect the yarn must be free at one end.

Some little difficulty may be experienced in threading the roving through the twister tube, and to remedy this, it is suggested that about 6 inches of fine flexible wire be used, say two wires twisted together, and the thread from the first rollers is drawn by the wire through the twisting tube to the second pair of drafting rollers. Obviously this would be a serious difficulty in a case of frequent thread breakages.

The driving of the tin rollers, which in turn drive the spindles and twisting tube, is done by means of rims which are placed at the end of the shafts, and are easily changeable.

There are movable ring plates and an ordinary copping motion to build ring bobbins in the well-known manner.

The spindle distance may be $2\frac{1}{2}$, $2\frac{3}{4}$, 3, 4, or $4\frac{1}{2}$ inches, to suit requirements. The lift may be 5 to 9 inches as required. Rings $2\frac{1}{4}$, $2\frac{3}{8}$, $2\frac{1}{2}$ inches inside diameter for warp, or $1\frac{3}{8}$ to $1\frac{7}{8}$ inches for weft, rising by steps of $\frac{1}{8}$ inch.

In the figure the various parts will be readily found from above description.

Kinds of Waste Returned to Mixings.

Lap ends, sliver and bobbin waste are the more usual kinds of waste returned to the mixings, the latter being now usually passed through a roving waste opener before going back to the mixing. Sometimes comber waste and even strippings of a superior cotton are cleaned and returned to the mixings for lower classes and counts of yarns.

The use of an excessive amount of waste is conducive to lap licking, roller licking, breakage of slivers at card and draw-frame, excessive breakage of ends at the fly-frames and spinning machines, and finally weak, irregular yarn. Extra twist must be put in at the fly-frames and spinning machines, accompanied by reduced production and greater cost of production. There will be excessive waste loss at the various machines and especially the earlier ones.

The proportionate degree of these evils will depend upon the proportion and quality of the waste, the fineness of the counts, and the cleanliness and suitability of the waste for the kinds of yarn being spun.

Variations in Card Sliver from Same Can.

In such cases it is very often the lap that is faulty, and we might first direct our attention to this point. As a rule the fault in the lap would be fairly apparent, but reference could easily be made to the weighings of full scutcher laps usually written down in the blow-room. If these appeared sufficiently correct a personal check might be kept for a time upon these weighings. It would, however, be quite possible for the weight of a full lap to be correct and yet short lengths of the lap to be quite variable, and a lap could be unrolled, examined, and two-yard lengths carefully broken often and weighed. These coming out erratically we should turn our attention at once to the various parts of the piano feed regulating motion, and see that the cone belt was sufficiently tight, the various rods and levers clean, free, and properly adjusted. Such work might be carried out both for scutchers and openers, and in connection with the latter the various mechanisms and actions of the hopper feeder could be carefully examined. At the card itself a check could be placed on the stripping, grinding, setting, and condition of the principal organs and likely details.

Fibres in Indian Cotton.

There is perhaps even a closer connection in the cotton waste trade than in ordinary cotton, between the spinner, manufacturer, bleacher, dyer and finisher, and this needs encouragement.

If any new cotton is considered for mixing with cotton waste it is usually Indian as this country gives the bulk of the shortest cotton staples. Sometimes the lowest grades of American cotton are obtainable cheaply.

Mr. Porritt quotes the Indian Trade Commissioner as stating that out of a total Indian crop of 4,600,000 bales of 400 lb. each, that the staple :—

$\frac{3}{8}$	to $\frac{1}{2}$	inch	is about	370,000	bales.
$\frac{1}{2}$	,, $\frac{5}{8}$	,,	,, ,,	600,000	,,
$\frac{1}{2}$	,, $\frac{7}{8}$	,,	,, ,,	1,200,000	,,

He continues :—

"All of this last is mixed, and a large proportion of it would run from $\frac{1}{2}$ to $\frac{5}{8}$ inch making a total of 2,170,000 bales.

"Before the war Germany took about one-eighth of the total Indian exports of cotton, whilst the United Kingdom took less than

one-third of what Germany did; the bulk of the cotton sent to Germany would be of the shorter staples.

"The condenser mules for counts 4's and above are fitted with a treble spindle speed in order to give increased production and superior quality of yarn. The first speed of the spindles is about 1,800 r.p.m. for 18 inches of the draw, then the second speed is accelerated to 2,700 r.p.m. until the carriage is nearly at full stretch, and the third speed is about 5,000 r.p.m. for twisting up." (These speeds are very high for a cotton condenser mule.—AUTHOR.)

Mixed Wastes.—Cotton wastes need quite as much care, skill, and discrimination in mixing as do new cottons, and it is quite as difficult to mix the wastes of Egyptian and American cottons as it is to mix the new cottons themselves. To the natural differences of colour and fibre length are added differences in twist per inch put in the yarn.

First principles in waste mixing are much the same as in blending new cotton, in such features as stock mixings consisting of layers of one sort placed over layers of another in proportioned quantities and forking down the face of each mixing.

It is reasonable to assume that cop bottoms and hard waste from coarse counts will differ in ingredient cotton, twist per inch, and other respects sufficiently to affect waste mixings and waste treatment.

CHAPTER XVI.

MISCELLANEOUS.

Case-hardening.

Perhaps the greatest example of case-hardening in the cotton trade is that of the bottom draft rollers of various machines in the spinning mills. In many cases the necks only are case-hardened. In other cases the rollers are case-hardened all over, especially in the front line of bottom rollers, but this is usually charged as an extra by the machine makers. The writer has been seriously questioned at times in regard to possible injury to cotton yarns due to case-hardened draft rollers. While there may be some little doubt in the case of fine yarns, it is doubtful whether much damage ever results to the cotton from the case-hardening. Case-hardening has been defined as "the conversion of the outer crust or skin of the mild steel of the rollers into hardened steel." The writer has examined many rollers specially cut for the purpose, and the hardening appears to extend for a depth of possibly $\frac{1}{64}$ inch or so, but is subject to some variation in the depth of penetration.

It would appear that different engineering firms employ somewhat different methods and use different substances to aid in the work. It is possible to obtain case-hardening compounds ready manufactured or mixed, and, in at least one instance, these consist of refined, rapid powders, graded according to the class of work to be performed by the case-hardened articles. These are best when non-inflammable and practically free from disagreeable fumes.

Perhaps the smaller engineering shops may benefit most from such powders.

Dyeing.

Cop Dyeing.—The usual method in cop-dyeing is to skewer the cops upon perforated metal tubes or hollow spindles, which are pegged upon cylinders revolving in large vats of dye. The dye-liquor may be pumped through the tubes and cops alternately from the inside and outside of the tubes. After dyeing, the cops may be dried in hot air and taken to a packing or making-up room, to be unskewered by young girls and re-packed for the weaver by women.

Such cops are mostly for use as shuttle weft. Care should be taken to preserve the apertures in the cops and to keep the cop noses in good order.

Hank Dyeing.—Hank dyeing may be for either warp or weft yarn, and the hanks may be hung by bars of wood and banded by boys, or bound together by sufficiently strong yarn. Now transferred to the dye-house in which they may be dyed by the hand.

Turkey Red Dyeing is of a special character, often expensive, much in demand, and done in special works.

Raw Cotton Dyeing.—Raw cotton dyeing is a long-established industry, and methods vary somewhat. The raw cotton, or cotton waste, may be placed in a large vat through which dye liquor is continuously pumped. Afterwards it may be placed in a whizzer, or hydro-extractor, which quickly removes the greater proportion of the moisture. Some kind of opening process may now be employed to give a moderately loose and open character to the cotton. Further drying may precede packing. Sliver dyeing of cotton is difficult, because the sliver is too delicate to handle.

Beam Dyeing has recently gained in use for warp yarns, as opposed to other methods.

Cloth Dyeing.—The cloth may be unwound in long lengths and drawn through dye-baths.

Gun Cotton Machinery and Processes.

More for personal information than as a possible buyer, the present writer on 5th December, 1922, attended a sale of machinery at the gigantic war-time factory at Queen's Ferry, near Chester. The cotton machinery section had been used in the cleaning and preparation of cotton, cotton waste, and cotton linters, intended for making into gun cotton. Machines mostly separately driven by motor.

1. The first machines were two excellent Platt's bale-breakers, as used for any hard baled material requiring treatment before reaching the willow. Each bale-breaker 36 inches wide, complete with 15-inch fan, proper coverings, guards, pulleys, feeding and delivery connections.

2. Cyclone separator for bale-breaker, with suitable galvanised sheet-iron tubing.

3. Great lengths of exhaust tubes and pneumatic plant for carrying the opened waste from bale-breakers to the willows or teasing machines in the willowing and teasing rooms. This pneumatic plant included 450 feet of 16-inch galvanised sheet-iron tubing, with 14 three-way pieces and 6 cotton receiving bins. Two C.I. cased fans, with 15-inch inlets and 12-inch outlets, 9-inch diameter pulleys. Two cotton receiving hoppers on breakers.

4. The cotton cyclone-room contained four sets of cyclone and fan complete.

5. For soft waste, especially if not hard baled, it was possible to omit the bale-breakers and treat the waste directly by a large willowing machine.

There was a Tatham's soft waste willowing machine, 56 inches wide on the cylinder, with patent feeder, dust grids, fan for down draught, patent movable roller, overhead delivery, creeper, patent dirt remover, and fixed pulley of 32 inches diameter × 6 inches width.

6. In the willowing and teasing rooms there were four complete installations, practically all alike, so that only one is described below.

The previously treated cotton or cotton waste was passed automatically through the complete combination from one end to the other, or from feed to delivery and over a floor length of 20 yards or more, and as summarised below :—

(*a*) Automatic hopper feeder.
(*b*) Cotton waste teasing machine.
(*c*) Connecting lattice between teaser and cotton drying machine.
(*d*) Cotton drying machine.
(*e*) Connecting lattice between drier and willow.
(*f*) Final cotton willowing machine.
(*g*) Dust collecting plant for last machine fan, with hoods and pipes.

(*a*) Each hopper feeder was 40 inches wide, contracted to 34 inches at delivery to the teasing machine.

Neither hopper feeder nor hopper bale-breaker calls for further description.

(*b*) Each cotton teasing machine presented a very different appearance from anything found in an ordinary cotton spinning mill, or even in many cotton waste mills. With covers down there was much the same general appearance as a roller and clearer carding engine. With covers up a totally different interior was presented to view.

(*c*) Each teaser was 40½ inches wide on the body, with hand feeder lattice, feed rollers. The main iron cylinder, of 45 inches diameter, was covered with hard-wood lags or cross-bars, filled with steel teeth of a stronger character than those of a hopper feeder lifting lattice.

The rollers and clearers were also covered with strong steel spikes or teeth.

There was an iron doffer of 26 inches diameter, an angle roller, calender rollers and delivery lattice.

Some of the feed parts were covered with the band of strong bent teeth used on some cotton preparing machines.

(*d*) The cotton drying machine calls for a little description:—

Class C, 29 feet 9 inches long × several decks high × 4 feet wide; with tubular heaters 9 feet 6 inches long, 3 feet 6 inches diameter. Special fans 40 inches diameter, complete with air shafts, with damper and operating gear. Each cotton drying machine consisted externally of a huge wood and iron structure, erected on long lines of bricks about 3 feet high.

The cotton from the teasing machine could be delivered on lattice work, which gave the cotton to the feed part of the drying machine.

Emerging from the drier after treatment therewith, the cotton was delivered to a willowing machine which again opened out and loosened the cotton.

(*e*) The drying machine was something after the style used often to dry cotton after bleaching, as briefly described below, on the continuous acting and drying principle.

The central apparatus is enclosed as described in a large wooden and iron chamber. Internally there are travelling lattices or sheet work of one kind or another for conveying the cotton at the required speed through the machine, and giving proper time for continuous and sufficient drying. Whatever kinds of conveyer are used, they are supported by rollers which are arranged to permit the cotton to fall of itself from one tier to the next lower, or from an upper to a lower lattice to give the required number of passages of the cotton backward and forward. The lowest lattice, in drier above described, delivered the dried cotton upon a lattice which acted as feeder to a special arrangement of Tatham's willow as described below.

The actual drying effect was obtained by means of tubes, or steam pipes, between which the air is blown in a manner which permits sufficient heating. The heated air absorbs the moisture from the cotton and is liberated through suitable tubes or other outlets.

It is well known that well-cleaned short, soft cotton waste is best for gun cotton. "Linters," or second ginnings, are sometimes used. After a thorough opening and cleaning by some such machines as above described, the oil, wax, proteins, and other unsuitable ingredients are removed by digesting with about 1 per cent. of caustic soda.

For this purpose the cleaned cotton must be tightly packed in suitable boilers with good circulation.

(*f*) At Queen's Ferry the final cotton willowing machine taking the cotton from the drier was fitted with side delivery, with framing, large toothed cylinder, excellent shaft pedestals, lattice feed, delivery cloth creeper, two spiked rollers over cylinder, undergrid to cylinder pressing roller, dust fan, fast and loose pulleys, and belt shifting tackle. Made by Tatham's of Rochdale.

Thread Extractor.

For some years past machines have been more or less in use for extracting hard ends and threads from the clearer laps of mules and ring-frames. Messrs. Brooks & Doxey and also Messrs. Tatham's have made machines for the purpose that have been in good demand.

Messrs. Tatham showed a machine at the 1922 exhibition in which there are important reconstructions, especially in regard to the central beaters or thread extractors themselves.

The writer was in the company of several mill managers—old students—when a demonstration was given.

There are three central beaters each practically of equal construction, each of small diameter, and each containing a good number of steel fingers. Their rapid revolution acted on the slowly fed clearer laps, tossed the laps about so as to loosen the threads, which latter naturally fastened round the beater shafts while the loosened cotton escaped at the delivery end under the influence of a fan draft.

The material is fed slowly from the top at one end, while delivery takes place at the other end.

Each beater shaft contains a longitudinal slot along which a specially constructed knife is run at intervals, in order to cut off the extracted threads.

One of the managers shrewdly remarked that the cotton was rather good because the threads in the untreated laps were comparatively few in number, showing there had been good spinning and few broken threads.

Under-clearers.

The under-clearers of the rollers of mules and ring-frames accumulate a good quantity of waste or laps of good quality fibre whose value is sadly deteriorated owing to broken yarn wrapping round the waste. On ordinary American cotton 30's to 40's, the present author as a piecer umpteen years ago had to strip or clean the "crows" at least once a day, with frequent odd pickings between. It is a sign of good cotton and good spinning when the under-clearers do not contain a large proportion of broken threads.

The thread extractor has come slowly into use during the last twenty years.

The under-clearer waste from ring-frames may, on the whole, contain a less amount of thread than the "crow" laps from mules, since mule threads—apart from unlocking breakages—break more often when the mule is nearly "out," leaving long lengths of thread to wrap round the clearers. Top clearers do not gather much thread waste. It cannot be guaranteed that every thread will always be extracted.

The thread extractor can scarcely be regarded as a perfect

machine, but it is a great advance upon hand picking, at any rate, for American cottons.

In this machine the threads are really extracted and not simply broken up into little bits, such as results from treatment by a bobbin waste machine or cop-bottom machine.

The central mechanical feature consists of three-spiked rollers properly encased and with an under-grid. First, placing the waste upon an upper tray and very slow feeding of waste enables an attendant to see and pick out any harmful material. The high-speed spiked rollers loosen the threads which then wrap round the spiked rollers, while the shorter and good waste is drawn away by a fan.

As required, the top cone is lifted and the threads cut off the rollers by a special cutter, there being a special groove in each roller to facilitate this.

Either loose cage delivery to the floor, or pipe delivery to the opener, may be arranged.

It is possible to apply a brake arrangement to more quickly stop the rollers for stripping the threads, and the upper cover is fitted with a safety lock to prevent lifting before the rollers stop. The brake is of most service when the rollers are fitted with ball bearings. Production 600 to 800 lb. per 10 hours. Extracted threads may be used as cleaning waste and the cleared "crow" laps used in the cotton mixing.

Preparing Machine.

The multiplied use of the fine-spiked cylinder, as in a 6-cylinder machine, offers the best known method of completely reducing hard waste or cop-bottom waste back again to a fibrous condition. Each cylinder may contain about 10,000 steel spikes.

Often, however, ring-frame hard waste, mule cop bottoms, or winder's waste, is so much entangled that a preliminary treatment is found beneficial. Foreign baled waste is perhaps the worst in this respect, being received in bales of about 550 lb. weight in very solid condition.

The Oldham willow has always been a favourite for this purpose, allowing any amount of time treatment, and being also excellent for removing bale buttons or any hard substances with little fire risk.

The Oldham willow, however, has never been of much use in really loosening hard waste, and of recent years what is termed the "Preparing Machine" has often been preferred, and is designed especially for heavy work, and much greater productions than are possible with the plain Oldham willow.

The machine is made up of a strong hand-feeder lattice, 1 pair of feed rollers covered with toothed discs, iron cylinder covered with hard-wood lags fitted with strong steel teeth, an iron doffer covered

with metal plates fitted with hardened steel teeth, two iron calender rollers, chain to drive feeder, strap moving apparatus, starting and stopping motion for doffer and feeder, iron cover over cylinder, sheet-iron casing underneath fitted with door, cylinder 250 r.p.m. in an upward direction. Waste either delivered loosely on the floor, or given automatically to the cop-bottom machine.

Cop-bottom Machines.

A 6-cylinder machine is sufficient for ordinary cop-bottom waste from yarn up to about 38's counts, American cotton. Fires have started in cop-bottom machines, and they are best operated in a separate fire-proof room, with ample fire-extinguishing appliances, and convenience for quickly taking away water used in fire extinguishing.

The steel spikes or teeth may be graded in number from first to last cylinder. Waste in this machine is opened into fibre and the cylinder strikes the cotton downward over a cutter plate.

It is important to carefully select and season the timber from which the lags are constructed as there are great stresses set up in opening the hard waste. It is also important to have the correct tempering of the steel spikes. Ball bearings are now much used for these cylinders.

The cylinders may be reversed about once per month to get the best effects from back and front of the teeth. Spare lags should be kept in a dry place for some weeks before using. Well-balanced cylinders, running with perfect steadiness, are indispensable.

For colouring purposes washing blue has sometimes been put in the soap water.

Waste emerging from the cop-bottom machine may be treated with soap water at a rate of possibly 16 gallons per 2000 lb. of waste, the soap water containing about 1 lb. soft soap per gallon of water, slowly boiled and kept agitated. The tank kept at one level regulated by ball tap. 12 to 24 hours for soaped waste to stand.

Twist in Condenser 3-speed Mule.

Perhaps the terms 3-twist mule would be more representative since the three speeds apply only to the twisting spindles. There are two rim-pulleys and two different diameters of driving pulleys to get the three different spindle speeds.

The rim-pulleys are not often altered in diameter for differences in twist per inch and from 4's to 9's have been spun with the same rim-diameters.

Suppose we wanted to increase the twist per inch, and double or second speed started with the carriage 12 inches from the beam. If

we quickly altered the change to put the second speed going at 9 inches from beam there would be increased twist per inch so long as no twist motion to correct it.

Carpet yarns on the preparation or semi-preparation system may be produced from mixings of blowings, willowed fly strips, etc.

Following the willow, there may be a hopper feeder, porcupine and Crighton, either coupled together or not so. A second Crighton or other opener may be sometimes used.

Roller cards with side-drawing, followed by a draw-frame with small diameter rollers, slubber, intermediate, and mule.

Possible for nets, ropes, sacks, sponge cloths, towels, belting, carpets, coloured twine, etc.

Sometimes doubled into about three-fold 8's or 9's which must pull per thread 4 or 5 lb.

In the quadruple card system it is possible to adopt the ring-doffer principle of having rings of fillet alternated with rings of leather, but in this case the fillet rings may be 11 inches wide for a 48-inch card, with $3\frac{5}{8}$ ring leathers between.

Fans and dust-pipes may be used on cop-bottom machines, when opening coloured or very dirty hard waste, but the draft from the cylinders is considered sufficient to throw the waste upon the cages when using clean cop-bottoms. There is less danger of fire spreading without fans.

Cop-bottom and hard waste treatment has been perhaps more developed in England than has the treatment of soft waste, a great deal of which is sent to Germany.

Quiltings, blankets, towels, sponge cloths and other goods do, however, consume a good deal of yarn from lower classes of soft waste.

Doubled hard waste, especially if cabled into several folds, is difficult to thoroughly break up, re-fibre without rendering the material of little value, although it is the most costly waste of any to the doubler.

Well seasoned beechwood lags are somewhat expensive, but iron lags would probably be dearer and would add too much weight to the cylinder.

The feed of cotton to each succeeding cylinder in a cop-bottom machine is best slightly faster and faster to each succeeding cylinder, to compensate for waste becoming more loose, open, and bulky. This helps the waste to clear through the machine better.

Roving Waste Opener.

Referring first to the lower counts of hank roving treated by the roving waste opener, the waste is fed by hand upon a lattice, under a pressing roller to treble-feed rollers, while the toothed cylinder

having a downward direction, combs out and opens the roving waste in a very effective manner. The draft caused by the cylinder carries the opened waste forward to the cage delivery and roller. Main cylinders, 750 to 800 r.p.m. Opened material stripped from cylinder by a back cutter plate. Opened waste delivered either loose on floor, or in a very slow manner to one of the blowing-room machines. While bobbin waste up to about $5\frac{1}{2}$ hank may be sufficiently opened by one ordinary machine, experience has taught that finer hank roving may require some additional treatment, such as an additional taker-in or cylinder. Along with the taker-in there may be a pair of fluted 2-inch diameter feed-rollers instead of the treble feed above mentioned.

Setting of feed rollers to taker-in or of taker-in to cylinder, may be about $\frac{1}{32}$ inch with these parts in good condition. Feed rollers driven from taker-in so as to prevent choking of taker-in. A cylinder may be 34-inch diameter unlagged, and $37\frac{1}{4}$ inches to points of teeth.

The lattice may either be of the customary wood lath character, or else a special metal lattice not liable to fire damage and more easily cleaned. The treble feed may consist of two upper rollers of $1\frac{1}{4}$-inch diameter, and one bottom fluted roller, $1\frac{3}{4}$-inch diameter. Being supplied with special long bearings the cotton waste is not liable to be plucked through. Ball and roller bearings are often fitted to the cylinders. As an alternative there may be a pedal feed, having a cross-cut $2\frac{1}{2}$-inch diameter feed roller over the pedal noses. One important firm makes a patent welded wrought-iron cylinder, the shell, arms, and bosses being all of wrought iron. The shell is in a continuous sheet, welded together, and is strong, light, and easy to revolve, having a steel shaft with hardened necks.

The use of ball-bearings reduces the starting effort, saves in lubricants, and therefore reduces possible danger of oil getting on the waste, and requires less driving power generally.

Hardwood lags fitted with hand forged steel teeth are often supplied, but sometimes pointed steel teeth with flat sides and heads. There are some who claim that the flat teeth have more penetrating power.

Production may be put down at about 600 lb. per 10 hours on the finer hanks or 700 lb. on hank roving of $5\frac{1}{2}$ or lower.

Lags to be kept in good order, cylinders well balanced, settings accurately maintained, parts sufficiently cleaned and lubricated, and good driving belts used for best results.

Chapon Spinning Machine.

This long-established machine on the Continent, and to some extent also in India, has recently made a good deal of progress in

England, after attracting very little attention over a long period of years.

The machine is, more or less, of the usual stationary frame character, as distinct from the more complicated condenser mule. It has recently obtained a considerable vogue for counts below 2's cotton, or in the parlance of "bump" yarns, from 52 yards to 104 yards per ounce. Instead of condenser bobbins being taken to the condenser mule, they are taken to the condenser Chapon spinner, which may or may not be fitted with draft rollers, according to requirements. For such counts as above specified, the rollers may be omitted and the condenser counts may represent the yarn counts.

This procedure brings the machine to be perhaps more of a rival to the roving frame condenser spinner rather than to the mule.

The overwhelming and essential differences for bleached wefts, as in Alhambra quiltings, are dependent upon the fact of the Chapon producing cops of bleached yarn ready for the shuttle.

The procedure for the condenser roving frame or the condenser mule would be to reel and bundle the yarn, and then submit same to hank bleaching. Afterwards the yarn may be re-wound on the pirn or jumbo winding frame into hard cops, to be unwound from the base when used as weft in the broad quilting loom.

In Chapon condenser spinning the initial procedure is complicated by the need for bleaching the cotton waste in the early stages —after a certain amount of cleaning has been done. The problem at the start resolves itself into the question of convenience and cost of bleaching in loose waste form, or in the yarn hank form. Card-room treatment will be affected by this. At the final stages, the Chapon spun yarn need not be subject at all to the expense of reeling, bundling, and re-winding.

Quilt manufacturers find the omission of these processes gives them a fuller yarn, which will give as full an appearance to the cloth, even when fewer picks are used. For some other goods the cotton or the yarn is, of course, dyed as well as bleached.

These matters have been personally investigated by the writer, in both the condenser spinning mills and in weaving mills using the yarn. It appears difficult to build quite as firm jumbo cops on the Chapon spinner as are obtained from the jumbo winder, and in some cases the already long shuttles of the looms have still further been lengthened in order to compensate somewhat for the softer Chapon cops containing a less amount of yarn.

Roving Dyeing, Sliver Dyeing.

Bleaching and dyeing have been experimented with on cotton in almost every stage of progress through the mill, including raw cotton, sliver, slubbings, rovings, cops, cheeses, warps, hanks, and

cloth pieces. The commercial success has been of a varied character. Hank bleaching and dyeing is yet the favourite method, as the yarn is so convenient for handling and for obtaining the full effect of the processes.

Beam dyeing has gained somewhat rapidly since the Armistice. Sliver dyeing, on the contrary, is up against the difficulty of handling the delicate, loose strand of fibres, and getting the sliver to go in and out of the proper receptacles without stretch or sticking.

For special purposes roving or slubbing may be extra twisted so as to become a low twisted yarn, dyed in this condition, then re-wound upon roving bobbins with reverse spindles to extract sufficient twist to give a normally twisted roving for the spinning machine. Some special effects in good class yarns are obtained in this way.

Cop dyeing has attained a good deal of practical success, but some people are preferring beam dyeing at the time of writing.

Belt Fasteners.

The proper fastening or piecing of belts directly affects the working economy of a cotton mill, and often forces itself before the notice of workmen, foremen, and managers. Badly pieced belts in spinning mills mean frequent stoppages, loss of production, and extra work.

Lap-over piecings have been in vogue as long as the machines themselves, and pieced up with either hard or soft buffalo or leather laces. During recent years what are known as "jump" or "butt" piecings have come largely into use instead of "lap-over" piecings.

Quite a number of patent belt-fasteners have received extensive adoption, along with special tools or small machines for helping to make the piecings. Amongst the special fasteners best known to the writer we have "Jackson's," the "Harris," the "peerless," and the "klincha."

The Jackson consists of special bolts, washers, and nuts. The Harris fastener is a small malleable iron casting after the style of small spiked boot protectors; the peerless consists of an endless thin wire, practically stitched across the end of each half of the belt, the two ends being then linked together by a buffalo or raw-hide pin, which acts as a hinge for the belt ends. The klincha consists of a good number of individual fine wires forced into each end of the belt in two lines of gripping points. The fasteners having a hinge of raw-hide pin certainly give a smooth running, strong, and quickly made piecing. At the 1922 Manchester Textile Exhibition various fasteners were on view.

The klincha method, for example, utilises any one of three methods of making the piecings, as shown in the latest developments at the Exhibition, 1922. Method one consists of a small portable

frame fitted with a holder for the row of wire fasteners, which latter are fitted into the frame and held in position by a wire pin.

The belt end is placed between the jaws of the wires, the strong lid of the appliance is closed down on the wires and belt end, after which a hammer is used to hit the lid sufficiently until the wires have clamped into the end of the belt. The opposite end of the belt is served similarly.

Afterwards the two rows of butt ends of wires are interlocked either at the cotton machine itself (or else away from the machine when an endless belt can be put on), and the raw-hide pin is threaded across to complete the piecing. A minute or two is usually long enough to make a piecing when the exact belt length has been got.

In a still more simple device to aid in making klincha piecings, a small and special kind of clamp is fitted between the jaws of an ordinary vice. The required width of coupled-up wires is placed in the clamp and fixed by a wire pin ; then the belt end is placed between the points or jaws of the wires, the vice screwed up gradually and forcibly until the wires are firmly and uniformly secured to the belt. Each end is separately treated as before.

There is yet a third still more ambitious, more recent, and more ingenious method of making belt piecings by the klincha fasteners.

This is a strongly-built lever arrangement, by means of which, after the wires and belt have been fixed in position much as before, the operator simply pulls gradually and nicely at one or two rods which cause a double incline to move forward, to come between the rear ends of two strong lever jaws, and thus to shut the said jaws upon the wires and belt-end in a very forcible manner without using either a vice or a hammer. The present writer has made good belt piecings by each one of these three devices.

The peerless is rather a more ambitious machine still, and threads a continuous length of wire from side to side of the belt in one straight line.

In either case each end of the belt is separately fitted with the wire, then the two ends of the belt are put together, and the piecing completed by threading a raw-hide pin through, or in some cases by means of strong string.

Belt-lacing machines of one sort or another can now be had in an inexpensive form, and are now to be found in almost any kind of works containing a number of belt-driven machines, so that devices for the purpose are on the increase.

In one device for making wire piecings the wire was turned in screw form. On the machine itself the holes for the wire were cut in spiral order by the machine, and then the end of the wire screw started in the correct position simply screwed forward into position by hand, and the butt ends then flattened out.

Yet another type was inspected by the writer at the 1922 Man-

chester Exhibition. This was less than £4 in cost, and only about 16 lb. in weight, so that it could be carried easily to the belt requiring piecing, in this respect, however, only equalling the several other appliances above described.

By its use the wire hooks are flattened into the belt by a single lever while the other hand holds the belt. By means of a rack and pawl fitted at the back of the lacer the pressure is gradually increased so as to fasten all the hooks simultaneously.

The staggering of the holes and wires, as also in the klincha, prevents weakening of the belt. The insertion of a raw-hide pin, as before, completes the piecing.

The peerless belt lacer is a device for joining belts, which operates by forcing thin wire in spiral fashion through the ends of belts of leather or woven material. The butt or rounded centres or projecting edges of these wires are then brought together, and hinged together by a raw-hide pen or by suitable string. Cost of fasteners is quite low, as in the case of other wire fasteners, but the machine itself has more about it than some of the others described. Any of the methods using a hinge of raw-hide pin can be fastened or unfastened almost in a moment if a good joint has been made.

The "Youlten" Opener.

No machine at the 1922 Manchester Exhibition attracted more attention from cotton spinners than the Youlten opener, exhibited in full size and with driving equipment, but not putting cotton through. Mr. Basil Youlten, son of the inventor, and who lectured at Bolton Technical School some months previously on this opener, was usually present to give full information and descriptions.

It is several years since the Youlten opener was first brought to the notice of the public, but the war held this invention up, as it did many others. At time of writing, Messrs. Lord Bros. of Todmorden are the sole makers. The treatment of fragile textile fibres by the Youlten opener is of a much less brutal character than many of the opening and beating instruments that have been in use for many years. The fundamental principle of treatment, in some respects, resembles that of the vertical or Crighton opener in that the cotton is not held at any point when under treatment, and passes away from the treatment as it becomes lighter and more opened out.

The exhibition machine consisted of the fundamental Youlten opener, appropriate cotton feeding arrangements, and a hopper and cage arrangement for carrying the opened cotton forward. Let it be understood that any of the well-known types of initial or blowroom machinery can be coupled up to the Youlten as to the "Buckley," "Crighton," or other opener. The feature that first catches

the eye is a large slowly revolving cage or sieve cylinder several feet wide and several feet in diameter. At one end of this horizontal sieve cylinder, and near the upper portion of the cylinder, a strong current of air enters, passes more through the upper portion of the cylinder, and then out at the other end. The so-called rotor, which takes the place of the beater, stretches across the length of the large sieve cylinder in the lower portion of the same not far from the bottom. Apparently it depends for its action somewhat upon attaining a high speed, and modern developments in ball bearings facilitate this detail. The rotor has a diameter more approximating to that of a two or three-blade beater rather than the diameter of a Buckley opener. The building up or construction of the rotor or opening instrument differs from any other beater in use for cotton. The rotor is built up of a considerable number of stampings fitted on a central shaft in double right and left-hand spirals. Each stamping is rounded at the edge or tip to prevent damage to the fibre, and the high speed—possibly 2,000 or more per minute—presents an evenly serrated and impenetrable surface to the cotton fibres. The spiral arrangement gives it the property of a screw conveyer from both ends of the rotor towards the centre, and the cotton is constantly propelled towards this centre. The multitude of taps given to the floating cotton by the stampings or arms of the rotor throws the cotton against the slowly turning cage and upwards, so that as the cotton becomes tight enough it moves upward within the full action of the current of air flowing strongly across the upper portion of the sieve cylinder, and is taken away at the exit end of the cylinder by an air current to cages and other parts in much the usual manner. One wonders whether there would be any tendency to "string" long staple cotton by the actions inside the large cylinder, but possible purchasers were invited to make tests with their own cotton at the makers' premises. One wonders, also, how much the fundamental principles of hitting the cotton when not held at any point really differ from those of some other openers.

The Youlten opener—like others—can be fed with cotton by a trunk from the room above, by a hopper in same room, or by trunk or lattice from room below. The cotton for treatment enters the Youlten opener at the same end as the air current, but lower down and nearer to the rotor itself so as to at once receive treatment by the rotor and tend to pass or throw higher as it becomes more opened out. Here again we have the fundamental principle ofthe Crighton, in which cotton has to be lifted upwards so that heavier and more matted portions of cotton tend to remain longer under treatment than lighter portions.

The cylindrical character of the large sieve cylinder, its slow revolution, its open-work cage or sieve construction—capable of varia-

tion as required—and its horizontal disposition, lend themselves to the application of a revolving cylindrical brush below the cage to keep the latter clean. Cage and fan arrangements are made for extracting the dust.

The special and peculiar features of the Youlten opener consist of a slowly revolving, large diameter, circular cage, a specially constructed high-speed rotor of small diameter placed on the lower portion of the large cage, the cotton entering at one end of the cage and leaving at the other in a higher position, and a revolving brush to keep the large cage cylinder clean. Suitable attachments and combinations of well-known opening machinery before and after the Youlten centre.

The production of the machine was quoted at 400 lb. to 600 lb. per hour for delivery to a lap-machine, or 400 lb. to 800 lb. per hour for open delivery, these productions being much the same as might be quoted for almost any good modern opener.

If by the Youlten, or any other convenient device, we can get the more perfect elimination of microscopic portions of sand and dust, we may expect to get a brighter yarn, and see a smaller amount of sand on our roller beams or on the floor beneath the rollers at fly-frames and spinning machines. Certainly the use of a small diameter rotor inside a large diameter cage cylinder provides a very large opening area.

Setting of Hopper Feeder.

Lord Bros. say: "The relative position of evener roller to lattice depends on the amount of cotton to be passed through the hopper, as well as the condition of the cotton, whether it is hard or lumpy, light or soft.

"It will vary from $\frac{5}{8}$ inch to $\frac{1}{8}$ inch between points of pins of evener and lifting lattice, but it is better to work nearer to the $\frac{1}{8}$ inch, or, say, $\frac{1}{4}$ inch, than to the $\frac{5}{8}$ inch, if sufficient weight can be got through. The vertical lattice can be speeded by the cone pulleys so as to let a thinner feed pass upward, and still give the required production.

"The speed of the vertical lattice can also be altered by changing a pinion.

"The delivery roller from the reserve delivery box must be lowered so that the distance between it and the delivery lattice does not exceed the size of natural exit from reserve box, but is better if lower still.

"The wiper roller must be set a distance of $\frac{1}{8}$ inch to $\frac{3}{16}$ inch clear of stripping plate.

"The lower opening of reserve delivery box should be rather less

than its upper or entrance opening, and if the desired production is not obtained both openings may be enlarged.

" In order to ensure a sufficient and regular feed, sufficient cotton must be passed from main hopper feed box, so that there shall be a return flow from the reserve box, after allowing sufficient cotton to pass forward from the hopper feeder."

Lap Testing Machine.

On Messrs. Cook & Co.'s Stand there was exhibited a new and novel machine for automatically testing and recording the degree of regularity in the thickness of lap sheets.

Weighing of full laps as a first and ready test of laps is of course a very old and much used method, not likely to be superseded by any external machine.

A second and less used method of testing is to unrol a selected lap and carefully mark off separate lengths of one or two yards in length, and weigh these to ascertain the degree of regularity in the lap sheet to a more searching degree than by weighing full laps. Messrs. Hamer & Birch at one time applied a sliver regulator to the coiler of carding engines in order to counteract the very great variation which they proved to exist in most scutcher laps when tested in small lengths. The draw-frame doubling principle, however, proved to be the best method of obtaining uniformity, and it remains the champion method in this respect to-day, as it has been since Arkwright's time.

Mr. Charnock's lap testing machine, as shown and explained —practically demonstrated by him to the present writer—appears to be a distinct step in advance, especially in these days of research and testing. The machine is much the same size as a small loom.

For testing purposes the lap is placed on the top of two rollers, and the leading edge of the lap sheet is guided between regulating rollers. The revolution of these rollers draws the lap sheet forward so that thicker portions depress the regulators, and thinner ones permit the regulators to rise on the same fundamental principle as the pedals of scutcher regulator. Each short top regulating roller is fixed in a cradle, and each cradle is connected by chain or flexible wire to the next adjacent one through the medium of a pulley mounted on a lever. The well-known "link" motion principle is obtained of a mechanical combination and connection of all the pulleys to the main lever, which is itself directly connected to the indicator finger.

The sum total of the pedal movement, in which some moving upwards may possibly be compensated by others going downwards, is finally communicated to the diagram. To obtain a diagram

which will clearly indicate small differences in average lap thickness, the actual thickness is multiplied eighty times in the leverages.

A clearly marked indicator diagram is obtained which permanently shows variations over just as great a proportion of the lap length as may be desired.

Not only may the diagram be retained, taken away, and examined, but alterations in fan drafts, in the "piano" motion, on the feeding mechanism, or other parts of machine may be made with a view to correcting errors revealed by the "lap tester" and fresh diagrams obtained after the alterations to see if any better results are obtained.

The indicator drum is slowly rotated so as to bring the length of diagram sheet beneath the pen of the indicator, the pen being moved laterally by its connection to the final movement of the regulating mechanism.

It is no uncommon thing for short lengths of scutcher lap to show variations of 20 per cent. or more, and if we assume 1 foot of card lap to be 20 per cent. lighter than the next foot, we must remember that about 100 feet of sliver will be represented by 1 foot of lap. As stated, however, the bulk of such unevenness is rectified by the doubling action of the draw-frame, and might be still more so if pains were taken to mix sliver cans better at the first or card draw box. In Charnock's lap tester there is an extremely sensitive regulator that adjusts itself to the average thickness of lap passing through; by means of levers carried in anti-friction bearings, the resultant indications are recorded on a paper blank divided into spaces of feet in length and weight in ounces per yard.

Types of Opener and Beater for Cotton.

1. *Buckley Opener.*—First developed more than thirty years ago by Mr. Buckley, of Taylor-Lang & Co., and since then continued to exercise a great amount of favour for different sorts of cotton, but perhaps more especially for Egyptian and good American.

A great feature has always been an up-stroke, with grid bars in latest arrangements over almost three-fourths of the periphery, and bars or nogs in the top cover. A 41-inch cylinder covered with knives or strikers. Made either with one or two cylinders, followed by a blade beater. 41-inch cylinder making 400 to 600 r.p.m., and production up to 400 lb. per hour for Egyptian, or one-third more for American.

2. Cylinder equivalent to No. 1, but with a down-stroke over the feed roller. Has been for many years a great favourite for the finer and better sorts of cotton. By applying a swan-neck delivery from this cylinder and also the 2- or 3-blade beater, one firm has recently much increased the cleaning capacity. Made either single

or double. Sometimes an 18-inch striker cylinder is used instead of the blade beater.

3. *Crighton or Vertical Beater*, as used for forty years or more; always a favourite for lower classes of cotton, and latterly has also gained favour for Egyptian cotton, especially since the introduction of the strong-fibred Sakellarides cotton.

4. *Hopper Bale-breaker.*
5. *Hopper Bale-opener.* } Hopper principle increasing in use.
6. *Hopper Bale-feeder.*

7. Two and three-bladed beaters, now having diminished use as being somewhat dangerous to the fibre, but yet possessing more searching cleaning properties than striker beaters.

8. *The Youlten Opener.*—The most recent type at time of writing. Consisting chiefly of a high-speed, small diameter rotor which throws the cotton upwards and sideways until the opened cotton is light enough to occupy the higher portions of the large and slowly revolving cage, and is then taken away by an air current. Too early for the writer to express very decided opinions. Rotor on ball bearings at possibly 2000 r.p.m.

9. *The Kirschner Beater* has been in use for more than twenty years but is not now largely used in England. Designed more especially to occupy the position and use of the 2- or 3-blade beater. Considered by some to be rather severe on the cotton at this stage—and especially upon long staple cotton—at any rate, Bolton managers have put it this way to the present writer. The Kirschner beater is built up of three strong wood lags, studded with strong spikes which certainly opened the cotton very well. Considered by some to string and nep Egyptian cotton. The thickness of each of the three blades has been thought to create an undesirable air current and the spikes to break up the leaf or seed so finely as to be afterwards extract. Has been much used for low class cottons.

10. *Exhaust Cylinder.*—A narrow striker beater often placed centrally on same shaft between two large fans used to draw the cotton through the long exhaust feed trunks often used.

11. *Lattice Feeder and Small Porcupine Cylinders.*—These are smaller cylinders than the chief openers, but containing the same fundamental construction of steel knives or strikers, about 4 inches × $1\frac{1}{2}$ inches.

Initial Processes of Cotton Mill.

Apart from the attention at present attracted to the new Youlten opener, there has been more improvement in procedure and mechanical detail of recent years, in the initial processes of a spinning mill than in any other section. The Nasmith comber, and still more recent double combers may be taken as an exception to above general statement.

An extra hard pressed American cotton bale may represent about 36 lb. of cotton per cubic foot, and a more ordinary pre-war bale possibly 23 to 24 lb. per cubic foot.

High shipping and transit costs during and after the war, led to harder baling wherever convenient.

Minimum beater treatment of cotton conduces to strength of yarn but does not always clean the cotton sufficiently.

Thorough opening and loosening of the cotton maximum regularity in the laps, and effective cleaning of the cotton must be obtained at a minimum cost, while maintaining the strength of the spun yarn. The cost of labour in a modern blow-room is extremely low, especially when large combinations are used. Neither is the carding cost in labour very much. Later processes are all much more costly in labour, reaching even to the simple process of winding.

Cylinder and beater treatment, the use of cages and fan drafts, calender flap roller, have existed for a great many years, with first principles much the same as now. The first scutcher dates back to before the year 1800.

Very heavy machinery is used for opening and cleaning cotton, but does not need very much attention. Research people, machine makers, and mill owners need to combine if much better or much different methods are to be adopted.

The lifting lattices, evener and stripper rollers of hopper bale-breakers now play an excellent part in the combing-out, loosening, and opening of the raw cotton. Cylinders containing short knives or strikers have gained in use as compared with full-width blade beaters.

Most spinning mills find it pays better to have the same cotton pass with reasonable quickness through several hoppers and cylinders, rather than have one machine treat the cotton an extra long time.

Working particulars of a mixing might be somewhat as follows: Egyptian cotton of 740 lb. per bale average. About 400 square feet of floor space and the mixing 10 to 11 feet high. Mixing requiring about 30 bales. In the mixing there may be a density of about $4\frac{1}{4}$ lb. per cubic foot for American, and $5\frac{1}{2}$ lb. per cubic foot for Egyptian. From three to six days is considered good practice for a mixing to stand before using. Even when cotton is fed direct from bale to hopper of a large combine, and there is no stack mixing, sufficient bales may be assembled near the bale-breaker, to have bands and corners off, and much of the cotton to stand thus for about two days before using.

In its simplicity, its capacity for operating on a great weight of cotton per week—50,000 to 100,000 lb. per week or more—and in requiring only unskilled labour, a hopper bale-breaker is a really wonderful machine. It is equally capable of use as a complete single machine, or it may be used as part of a large combination of

machines, having one feed and one delivery of the cotton. As part of a combine its production may be limited, but as a separate machine, it may operate upon over 3,000 lb. weight of cotton per hour of Egyptian cotton, or 1,800 lb. per hour of American cotton, the more fleecy nature of American resisting quick passage forward more than the heavier and more compact Egyptian.

Both round and square tubes or trunks have been used for exhaust purposes, but round pipes or trunks of 10 to 11 inches diameter are preferred by many, with trunk and fan capacity to give 1,500 to 1,600 cubic feet of air delivery per minute.

It has been estimated that the dust chamber below a blow-room should have a space capacity equal to about 1,000 cubic feet for each fan used. A dust chimney should reach almost a dozen feet above the building it is connected with, and have a good area and not permit back drafts. Used first in the English woollen trade, then developed for cotton in America, the hopper feeder was introduced into Lancashire cotton mills soon after 1890, and has since proved the basis of most blowing-room developments, so that it may be termed the greatest invention for 100 years for opening cotton. Some of our great textile machine firms have experimented a great deal of recent years in order to still further perfect blowing-room processes in the way of reducing labour cost, and need for attention, while also obtaining better cleaning and opening.

Mostly along the lines of improved trunk arrangements for carrying the cotton from bale-breakers to mixing lattices, and from hopper feeder to opener; swan neck arrangements of beater bars, improved exhaust cylinders and huge combinations of several machines into one, as many as six, seven, and eight even machines being arranged to have only one feed and delivery.

Example for American cotton: (1) hopper bale-breaker, (2) hopper opener, (3) hopper feeder, (4) lattice feeder, (5) Crighton or vertical beater, (6) dust trunk, (7) opener exhaust cylinder, (8) lap-making scutcher.

Even for Sakel cotton above combination has been used minus one or two of the details such as the bale-breaker, and possibly the blade-beater part.

Under the term of "hopper opener" one firm has combined the first three of above details into one machine suitable for either Sakel, hard-pressed American or Indian cotton, and combined with just as many of the later details as may be deemed best.

The central part of the triple hopper arrangement has specially given to it the name of hopper opener to distinguish it from the hopper bale-breaker and the hopper feeder.

This hopper opener possesses a very strong evener lattice and a specially strong lifting lattice, the spikes of the latter being riveted into metal casing and arranged at an angle of 24 degrees to the lattice.

The spikes of the hopper feeder are much finer than for the bale-breaker or hopper opener.

The principle of the well-known swing door filling motion for hopper feeders is extended and developed to keep one hopper equal to another in feeding and delivering the cotton. The chief underlying principle consists in weight and bulk of cotton automatically determining of itself whether any more cotton shall enter a feed-box for the time being.

A recognised defect of the piano feed regulator is that bulk of cotton controls the regulation, whereas it is weight per yard which really matters, and in this respect a feeder controlled only by weight of cotton would probably be on more correct lines.

In the combination above described the exhaust cylinder may have a powerful fan at each side of the narrow exhaust cylinder, and these fans cause an air current sufficiently forcible to draw the cotton from the cylinder of the lattice feeder, through the swan-neck connecting tube, from bottom to top of the vertical opener, and through the narrow exhaust opener. From the exhaust opener another fan draws the cotton forward to the first pair of cages, and yet another one to the second or final pair of cages.

It has been stated that about 1,350 to 1,450 cubic feet of air per minute is normally required to spread the cotton properly on the cages, but this will be affected by the type of beater, direction of beater stroke, width of machine and construction of cages.

Crighton Opener for Egyptian Cotton.

Twenty to thirty years ago it was a stock belief that the Crighton opener was a very dangerous machine for Egyptian cotton owing to its great opening and cleaning capacity. However, for some years past many mills have been obtaining good results from the Crighton even when using long, staple Egyptian, such as six X Sakellarides of 1½ inches length.

The cotton is not held rigidly at any point when struck by the knives of the Crighton; the knives are too far apart for damage to fibre under proper conditions; the fan draft can be made sufficiently strong to draw the cotton upwards and away before there is fibre damage, speeds can be sufficiently low, and settings sufficiently wide to prevent damage.

Improvements in details of the machine have also been made of recent years. The knives or strikers on the circular plates have been arranged on the screw principle, the plates put closer together. One good firm, for example, make up for short cottons the vertical beater with 6 plates or 34 strikers, and for longer cotton 8 plates of 33 strikers, but with equal length of vertical shaft and surrounding grid,

The screw and lever arrangement, elsewhere shown in this treatise at the foot of the Crighton opener, allow ready adjustment of grid to cylinder. 148 grid bars are stated for Sakel cotton, 168 for good American or lower Egyptian, and 188 for Indian or low American.

The pre-treatment of cotton before going to the Crighton, and regular feed of cotton, help in obtaining the best results. The unusual method has been adopted of making 700 r.p.m. for Egyptian and 800 for American.

The swan-neck idea of delivering the cotton from the porcupine feeder to the Crighton has been adopted by at least one firm, so that the porcupine has cleaning bars acting over more than half its periphery—r.p.m. 1,000.

The travelling lattice inside the long exhaust-feed trunk is scarcely as necessary as formerly owing to the extra cleaning power of modern blowing-room machinery.

The speed of an exhaust cylinder should be no more than what is necessary to draw the cotton through the feeder, the vertical cylinder part, and the dust trunks.

So long as the cotton is drawn regularly and uniformly forward, then the slower the better in order to obtain the maximum cleaning and opening. Productions quoted at 500 lb. per hour for Egyptian and 700 lb. per hour for Indian cotton.

Charnock's lap tester is designed to test laps for uniformity over any portion of length and also to record the variation. A much adopted mill method is to unroll a lap in front of a good light and carefully examine it.

There are cases of 5 or 6 laps being fed up to a scutcher instead of the standard of 4 laps. Such high doubling is somewhat against effective scutcher treatment unless the laps fed up are very thin and of light weight per yard.

The beats per inch of feed of a 3-blade beater at nearly 1,000 r.p.m. and delivery approx. 700 lb. of American cotton per hour are quoted at 18.

Pneumatic Card Feeder.

More especially for the lower counts of cotton waste it is the custom to arrange breaker and finisher cards into one combination, with a Scotch feed or else a broad-band feed connecting the two.

One of the larger and more prominent new devices for cotton waste mills shown at the 1922 Exhibition consisted of a pneumatic card feeder, apparently designed to supersede the breaker card in the case of a breaker and finisher installation for the carding of cotton waste, and coupled together by means of a Scotch feeder or its larger equivalent, "the broad band feeder."

A full working arrangement was frequently operated to demonstrate to interested parties the possibilities of the new departure.

Assume now that the breaker card is entirely dispensed with in such a combination. In its place the "Stott" machine, as shown on Messrs. Cook & Co.'s stand, and demonstrated to the present writer by an interested person in Mr. Clement Charnock, apparently takes up a less amount of floor space than the ordinary roller and clearer breaker card.

The fundamental principles of Stott's pneumatic card feeder appear to be entirely different from those of the roller card, and there is very little resemblance between the two either in construction, design, or action. The roller and clearer action is dispensed with, and there is no substitute action in regard to the use of card clothing at any rate.

In place of card wire there is substituted a novel and extended application of the air current or fan-draft principle, and reliance is placed on extraction of dust, dirt, short bits of fibre, and any other small undesirable matter rather than upon the loosening and separating effect of numerous card teeth acting on the fibres.

The new feeder is designed to feed the cotton directly to the finisher card as opposed to the method of using the sliver lap machine or Derby doubler between the two.

There are three chief methods of giving the cotton to the breaker card when this is used. (1) Hand-spreading on the card feed lattice; (2) using a specially designed hopper feeder; (3) placing two scutcher caps on the feed lattice. No. 1 method is now seldom used while No. 3 is the most used.

Assuming this No. 3 method to be applied to the pneumatic feeder under description, the cotton is first treated by much the usual form of taker-in striking the cotton from the feed rollers and doing a considerable amount of opening and cleaning of the cotton.

The writer's experience is that the licker-in teeth of a waste breaker card are very liable to damage, and for this reason he prefers the teeth to be fixed in a leather foundation so that the teeth will more readily give way to hard substances, and the taker-in may be more readily re-clothed after damage. The metallic taker-in is more rigid in its work and is more difficult to re-clothe. Between the feed and delivery lattices there is bold vertical standard and trunk combination with a fan arrangement at the top. The opened cotton waste is taken from the licker-in upwards by the air current. A good deal of liberated dust is removed and the cotton flows downwards again to the delivery lattice which helps to couple this pnuematic feeder to the finisher carding engine.

The flow of air takes the cotton fibres from the licker-in in a manner unlikely to damage the fibres.

The down trunk through which the opened cotton passes is

utilised as the equivalent of the Scotch feeder rollers in being slowly traversed backwards and forwards over the delivery lattice of the combination.

The well-known half overlap of the narrow ribbon of the Scotch feed is utilised to give a sufficiently regular doubling and feeding of the cotton to the finisher card.

Condenser cages and a fan draft are utilised on much the well-known principle of a scutcher in order to pass the cotton forward in sheet form to the finisher.

Just as it is necessary in a breaker card, Scotch feed, and finisher card combination, so it is also necessary in this case to regulate the feed and delivery of the pneumatic feeder, to the feed of the finisher card, and so that the condenser strands shall be sufficiently regular in counts.

For example, if heavier condenser strands are wanted, the feed of cotton to the pneumatic feeder may either become quicker, or else keep the same speed and become thicker.

Colour Mixing at Carding Engine.

A typical experiment made by the author, 20th December, 1922. Across the full width of the lap behind the card, for about 2-inch length of lap, dyed red cotton was carefully spread.

Over 100 inches of well blended sliver was obtained therefrom, showing half red, half white.

At the first draw-frame, fed with six ordinary white slivers, the red portion showed up in one definite line in delivered sliver.

After the second draw-frame, the definite red line was still maintained, weakened of course to the extent of the draft.

Although very faint from the third or final draw-frame, yet the definite red line was still maintained.

It was made quite clear that the colour effect did not blend and spread all through the thickness of finished sliver, as contended in some quarters. Each cross-section of sliver contained its proportion of colour, but the colour kept itself always in one definite line instead of spreading all over the area of sliver.

Dawson's Semi-Combing Guides.

During 1922 a good deal had been heard of the Dawson so-called semi-comber, very strong claims were made for this type of cotton or sliver guide, patents being obtained in several countries. At the Manchester Exhibition of October, 1922, the writer examined three examples of this special type of sliver guide, one to come in front of the sliver trumpet hole of a carding engine, one for the similar position of a draw-frame, and one for the coiler top. The guides are

obviously simple and easily applied, and cannot be costly to make. Briefly speaking, instead of following the usual principle of having plates and guides as level and smooth as possible so as to give the least possible resistance to the passage of the cotton fibres, Dawson's semi-combing guides apparently work on the principle of offering a slight resistance to the free and easy passage of fibres. A good number of very slight round projections are raised on the surfaces of the guides with the idea that any crooked fibre ends will be drawn straight or parallel in passing over the guides.

Whatever may be the exact nature or type of resistance offered, this mild resistance to the fibres appears to be the fundamental idea.

At the carding engine delivery the well-known crossed character of the cotton fibres is at once altered in the direction of becoming parallel, and at the delivery of the drawing, the already approximate order of the fibres is improved. We understand the term, "semi-comber" has been applied because it is claimed that the extra parallelisation of fibres, and the possible increased rubbing out of some of the smaller mineral matter, result in increased strength and lustre in the yarn. It must not be forgotten however, that the primary duty of combing is to extract short fibre, and more incidentally to extract dirt and make fibres parallel. Good references have resulted from practical mill trials, but one wonders how small accumulations of fly will go on and whether any other practical defects will show up later.

Tunstall Comber.

Made by the Alsatian Machine Co., of America, and shown at 1922 Exhibition in Manchester.

An outstanding and distinctive feature of this double comber, as compared with the Hetherington, is that the two sides of the Tunstall comber are quite interdependent — stopping and starting together.

The Tunstall is perhaps more correctly described as a double comber, and the Hetherington or Nasmith as a twin comber, in which one side may be stopped or started and operated quite independently of the other.

Each type may be said to carry its own particular features, since the twin comber allows one side of six heads to run while the other side of six heads runs on, but the Tunstall permits the linking up of both sides from the same central organs, and works on the assumption that stoppages need not be sufficiently frequent to trouble about twelve ends stopping at once, while some people may not care to work on one side of a twin comber while the other side is running.

In the Tunstall comber there are no cams employed for operating the nipper, detaching rollers, and top combs.

Each side of six deliveries has its own coiler and can arrangement, so that two sliver cans are being filled together.

The top combs are more or less continually cleaned by the action of the nippers, and the cleaned fly passes along with the waste.

The top combs are quite independent of the nippers in the sense that the combs are far enough away from the nippers not to be affected by the nippers. The top combs are set to the detaching rollers, and their position need not be altered for a change in the percentage of waste.

The backward and forward swing of nippers, top comb, and back top detaching rollers as made familiar by the Nasmith comber, are adopted in the Tunstall double comber, although the swing may not be as great.

After being stopped all night, the writer saw this machine started up first thing next morning without any trouble, although the floor was shaky and the atmospherical conditions were anything but favourable. This central headstock for combers was suggested twenty years ago in the author's comber treatise.

Drawing Head.

A detail of the drawing head of four pairs of rollers consisted in the second bottom roller from delivery or front being placed on a slightly higher level than the other three lines, causing also the corresponding top roller to be higher than the others. It was explained by Mr. Halsall that this helped to deliver the combed cotton fibres in a better manner to the front or delivery rollers. A light paper sliver guide between these two pairs of rollers helped to give good selvedges to the sliver, and rested on the bottom clearer instead of on the sliver. Every effort is being made to make the Tunstall comber a greater success.

Nippers.

The interdependence of the two sides of the Tunstall comber is strongly manifested in the bonding together of the mechanism for swinging the nippers, the opposite nipper mechanisms being coupled together and operated by a single swing shaft. A powerful master lever operates both sides.

A single and simple adjustment in the headstock controls the approach of the nippers to the detaching rollers, and in this way regulates the percentage of waste.

Each nipper mechanism is built upon a rigid frame hung from an oscillating shaft between two stands. Fastened to the bottom of the frame is a cushion-plate carrying the *single* feed per head that is used. The nipper knife is fastened to the milled faces of two arms which are keyed to an oscillating shaft in the frame. The nipper is moved forward by the arms of the main swing shaft, and

is drawn into combing position by the springs which connect it to the opposite nipper. There is very little chance of backlash or lost motion during the swing of the nipper, owing to the perfect contact which the nipper frame maintains against the bowls on the swing shaft arms.

The nipper is closed by springs as it approaches the combing position, and remains stationary while all the needles of the half-lap pass through the fleece.

The nipper knife is raised during the forward swing by means of a hardened incline which can be adjusted with the greatest exactness both with regard to height and timing.

Like the single Heilmann, and the single Nasmith, both the double and the twin comber maintain Heilmann's fundamental principles of positive combing by cylinder needles, while the fibres are held by closed nippers, and then negative combing by the cotton fibres being drawn by detaching rollers through the needles of a top comb.

Nasmith "Twin" Comber.

The last note in the author's treatise on "Cotton Combing Machines," published in 1902, referred to a new combing machine by Hetherington's, which was just then under first trials.

Since 1902, more than 9,000 of these Nasmith combers have been made by Hetherington's up to November, 1922. About 1912, a Nasmith comber was placed in the Bolton Technical School, the number on the face-plate being 3,458. Continuous progression is thus indicated, and there are now other firms making the so-called Nasmith comber.

One would have thought almost the last note had been made on the basic principles of cotton combers and details of mechanism, and yet two of the most attractive machines at the Manchester 1922 Exhibition were two cotton combers, viz. the double comber of Tunstall's, and the Nasmith double comber. Both combers had already been subject to considerable experiment and trial in the mill, and both types are receiving extended mill trial since the Exhibition.

The inventor, Mr. Nasmith, lectured on his new comber on 6th December, 1922, at Bolton Technical School, before the long established overlookers, managers, and mutual class. A practical discussion followed a lecture illustrated by ordinary lantern slides and also by moving pictures showing the machine at work.

The idea of a double comber was experimented with almost as soon as the Heilmann single comber began to make its mark. Fothergill's patent for a double comber—shown on screen by Mr. Nasmith — dating back to 1853, Heilmann's comber attaining practical success in 1850.

Again, in 1883, a double acting comber was produced, but without mill success.

The Alsatian comber, and the much more successful Duplex comber, were also examples of obtaining two combing operations in place of one to increase production. The Duplex cylinder contained two sets of needles and 4 half-laps on the same periphery, each half-lap containing 13 rows of needles. 120 nips a minute on a Dobson's Duplex only represented 60 revolutions of cylinder. This Duplex comber lost favour partly because of abrupt over-quick actions of central organs, and reduced combing quality.

The Tunstall double comber has been previously referred to.

As a young man Mr. Nasmith had practical experience of the Lecuer comber of which about 400 were made for Continental mills, and which would comb staple as short as the lowest classes of American, but the produced yarn did not find a market in this country.

A double comber with an oscillating cylinder was introduced without success as might be expected from the principle of reversing a weight equal to possibly 1 cwt. from 80 to 100 times per minute.

Without being greatly enamoured of the project Mr. Nasmith made a double comber first in 1911, and has worked ever since more or less on the idea excepting for the four years of the war.

By 1915 sufficient practical success had been for a double comber to be installed at the Broadstone Spinning Company and had worked up to the date of the lecture, although many details had since been improved.

Mr. Nasmith contended for the idea of each half of a double comber being separately started and stopped, and for one tenter having 6 comber front alleys in one straight line, for better attention capacity, and minimum of danger.

The Nasmith twin comber may possibly give 50 per cent. increased production without reduction of quality, as compared with the older single Nasmith; extended mill trials, however, are yet required to definitely establish all the features for and against the principle of double *v.* single combers, and the best method of carrying out the idea of a double comber. The present writer in his 1902 treatise, suggested placing the headstock of a comber in the middle, exactly like a self-acting mule, with a comber on either side of the central headstock, and clutch mechanism for stopping and starting each side independently, and without touching the main driving belt of the double comber.

The present Nasmith twin comber, termed the 1920 model, really consists of two separate combers placed back to back upon central framing, driven either by one central belt or two separate belts.

The most obvious advantage is primarily a saving of floor space, and the most obvious disadvantage is primarily the difficulty of getting to the back.

This latter point is chiefly met by altering the central organs so

that any part and any adjustment may be conveniently got at from the front, and this feature has received great attention in detail.

The Roth aspirator reduces the need for attention at the back to the extracted waste. Even half-laps can be readily taken out at the front, and each top-comb can be easily lifted clean out of the machine without using a key. Brushes and doffers are not perhaps quite as easy to get at, but do not require very frequent attention, and sufficient provision is deemed to have been made for this feature.

Top Comb.

In reply to query the lecturer stated that the top comb practically occupies a standard position so that it need not be altered for any difference in waste per cent. Nipper adjustment is depended more upon for waste alterations. The top comb may be either lifted clean out, or it may be raised and pulled forward into a notch or slot, cleaned while it is conveniently suspended, and then pushed back into working position.

It is quite possible to arrange for one-half of the Nasmith twin comber, to be separately constructed and used as a single comber; and it remains to be seen whether it will compete with the ordinary and better known Nasmith comber on these lines.

Feed Parts.

The well-known single feed-roller of the ordinary Nasmith was absent in the exhibition comber, and in its place was used a positive grip so-called "nipper feed." The principle of a secondary nipper is not original to the "twin" Nasmith, but this particular and exact method of application and arrangement is novel and is patented. This secondary or feed nipper may slide within the real nipper.

At the correct moment—from 80 to 100 times per minute—the jaw of the feed nip tightly grips the cotton sheet and holds the cotton more firmly, and at a more forward point than the ordinary feed roller. A peculiar feature consists in feeding forward rather more cotton each time than is required—say instead of about $\frac{1}{4}$ inch, possibly $\frac{1}{16}$ inch to $\frac{1}{8}$ inch more, and when detaching is finished, the feed nipper draws the excess length back again into the real nipper before the latter close again.

Mr. Nasmith referred to the peculiar feature of this secondary nipper helping to give about 5 per cent. more waste than a round feed roller with same settings, but was not yet sure that the extra 5 per cent. ought all to come out. Instead the secondary nipper could set back $\frac{1}{8}$ inch and extract same per cent. but get cleaner slivers.

The excess feed of cotton having been drawn back by the secondary or feed nipper, this feed nipper then opens and moves back to grip the cotton farther up the sheet of uncombed cotton and bring forward a fresh portion.

This feed nipper is considered to be suitable for any length of fibre, or any feasible thickness or weight per yard of lap sheet. The twin comber was shown working different weights of lap from 18 to 32 dwts. per yard, on different heads.

Something like 33 per cent. less space is required for the twin comber than for the ordinary Nasmith and equal number of heads.

The Nipper.—The index is on much similar lines to the ordinary Nasmith, but there is a little difference in timing. One mark alteration of nipper might represent 2 per cent. difference in waste and top comb remain untouched.

In the older single Nasmith a question was often raised in regard to the varying distance of closed nippers from cylinder needles. Mr. Nasmith contended that this had the great advantage of allowing the needles to enter the fibres more easily than with fixed nippers, and this advantage is greatest for heavy lap weights, such as 18 to 26 dwts. per yard, than for the lighter Heilmann laps of 12 to 15 dwts. per yard.

Mr. Nasmith showed by lecture diagrams the arc of movement made by the nipper jaws in relation to the cylinder needles, both in the older Nasmith and in the re-arranged nippers for the twin comber, in which it does not matter how the nippers are adjusted in relation to the detaching rollers—for purposes of waste percentage—the relation of nippers to cylinder needles remains unaltered. The alteration has been made quite as much to meet expressed opinions of some other people as it has to meet Mr. Nasmith's own ideas.

By carrying the hinge on which the nipper swings on a lever pivoted on the boss of the cylinder shaft bearings, the desired result has been obtained.

By means of "setting" rods each of these nipper levers is connected to a setting shaft having a marked sector on its end in order to show the amount of alteration. After the nipper pivots have been all set in line, it is possible to move all of them simultaneously by a slight turning of the setting shaft in its bearings, so as to alter the distance of all nippers to detaching rollers, while maintaining concentricity of nipper pivot cylinders. Not only is there no change in nippers from cylinder needles, but no change takes place in any nipper movements, or in movements of top comb and feed nipper.

As the nipper is adjusted further back from the detaching rollers, it is now raised slightly higher, instead of being lowered as formerly, thus affording better support for the lap at the back of the top comb and increasing the efficiency of the latter, and yet not setting the

nipper so far back that long fibre is taken out and waste made greater. It is claimed for this nipper and feed re-arrangement, that a heavier lap can be used, and greater cleanliness obtained with same waste, or equal cleanliness with less waste.

Mr. Nasmith made a great point of the new nipper lip having to make only $1\frac{5}{8}$ inch movement as against 2 inches for the older Nasmith, with more like 3 inches for the heavy parts above the lip and more distant from the pivot on which the nipper swings. Allied to new $1\frac{5}{8}$ inch movement, all the interior parts lie between the pivot and the lip and therefore move less than the lip.

It is claimed that the power necessary to rock the nipper in the new twin comber is only about $\frac{1}{4}$ of that required to control the nipper of the older Nasmith, and therefore there is not the same tendency at high speeds to swag the full comber.

The top comb—no lightweight on the Nasmith comber—is removed from the nipper completely, and works on its own fixed pivot irrespective of the nipper, although controlled from the nipper shaft.

Detaching Roller Weighting.—The familiar 40 lb. weights of the Heilmann comber for detaching rollers are absent from new and old Nasmith combers.

In the "twin" comber the detaching roller weighting has been re-designed, so that increased weight is obtained just when these rollers are required to exercise their full drawing-off powers, but the weight is automatically reduced at other times, such as when starting to back-off and reverse the rollers. This is much better for the leather covering of the rollers and also reduces the driving power required.

When the detaching or forward motion has been definitely commenced, the pressure begins to come on the rollers, and increases up to the finish of the delivery or forward motion.

The increased pressure at the finish of detaching helps to a clean separation of the fibres, and prevents long straggling fibres from going into waste. This helps along the idea of using a heavier lap weight—possibly up to 35 dwts. per yard if ever required.

1. Reduced strain on driving mechanism when reversing and starting the rollers.
2. Greater life of leather coverings of detaching rollers.
3. Fewer long fibres pulled into waste.

For the detaching roller driving, the cam and sector idea has been retained, but not the roller-box. Quicker mechanism is used, not requiring a dwell on the cam at the point of going in or out of gear. An easier shape of cam is utilised. With twenty rows of needles on each half-lap, the main cylinder is 6 inches diameter.

The Exhibition machine on one head used a lap of 35 dwts. per yard Egyptian cotton, $\frac{7}{8}$ American; on another head 25 dwt. laps

were also worked. Waste on one head, 5 per cent., and on another, 15 per cent.

Diameter of Ring-frame Bobbin.

It may be taken as a pretty general rule that anything which alters the relative diameters of bobbin and ring is likely to have some effect on the yarn tension and may need a different weight of traveller.

1. In a certain case the ring jobber is called upon to change from ordinary wood ring bobbins to export tubes of smaller diameter. In this case he changes his traveller from 4/0 to 6/0.

2. In a second case there are ring-frames in the same room, using the same kind of empty bobbin, and spinning the same counts and kinds of yarn, but one having $\frac{1}{8}$ inch smaller diameter of ring than the other. It is found best to give the larger diameter of ring a slightly lighter traveller to relieve the slightly greater yarn tension due to different angle of the yarn.

The Revolving Flat Card.

About 1890, and later, the writer was frequently in touch with mills under process of substituting revolving flat cards for roller and clearer cards. The flat cards require much less looking after and give a much greater cleaning power, but often it was said that a weaker yarn resulted. Be that as it may, $1\frac{3}{8}$ inch flats speedily took the place of $1\frac{5}{8}$ inch flats so as to give still more cleaning power.

One of the most recent ideas undergoing mill experiment is to strip the wire from a certain number of flats at regular intervals so as to reduce the carding power of the flats proportionately. It is claimed that, for certain sorts of yarn and using certain sorts of cotton, there will be obtained a clean enough quality, and yet there will be a reduced amount of flat strips, and if anything a stronger yarn. Reduced carding is opposed by many good men.

If vacuum strippers are used for strippers, many firms also prefer to strip by the stripping brush about twice per week.

Chain drive for the "Swing" Motion of Bobbin and Fly-frames.

An ordinary bobbin and fly-frame for cotton is rather a complicated machine—not near so much so as a self-acting mule—and yet it is comparatively free from breakdown. Perhaps there is no part of the frame more likely to give a breakdown than the "swing" train of wheels which links up the differential winding motion to the first long bobbin shaft. The possibility of breakdown—worse in

some frames than others—and the slight gaining and losing of bobbin speed due to the "swing" forming an epicyclic train of wheels some years ago led to the introduction of chain driving for the "swing." On page 101 of Thornley's Intermediate Cotton Spinning (revised edition) there is described a chain "swing" motion, as made by Lord Bros., of Todmorden, and successfully applied to many frames. It appears to the writer that this is really the best basis for a "swing" drive, and up-to-date developments in the construction and application of chains ought to remove any obstacles to their extended adoption. It does not follow, of course, that there would be no wear and tear whatever of chains, and no possibility whatever of breakdowns, but, after all, modern chain driving does favour its adoption in this position.

The writer examined with interest a working size model of an up-to-date chain "swing" drive for fly-frames exhibited on Messrs. Cook's stand at the Exhibition. The chain and wheels were of exceptionally strong and flexible construction. The chain encircles a suitable driving wheel as the terminal wheel of the "differential," and at its other end encircles a suitable driven wheel on the first long bobbin shaft. There is a swing "Jockey" wheel resting on the chain between driver and driven wheel to maintain a correct tension. Such a combination is bound to reduce noise, vibration, and concomitant coils.

Chain Driving.

Many applications of chain driving were shown at the Textile Exhibition besides the swing drive.

Several firms, such as Hans Renold, and The Coventry Chain Co., showed modern applications of chain driving to cotton mill shafting or machinery.

The use of chains has certainly extended the purposes of power transmission, but it can scarcely be said that it is yet used a great deal in cotton spinning mills.

It is claimed that the loss of power in chain driving due to friction does not exceed two per cent. in a well-designed application, and ought not to appreciably increase during the useful life of the gear.

Mule Drawing-up.

Frequently it is only actual trials that will definitely determine the genuinely best speeds for the drawing-up of a mule. Substantial gains in production have sometimes resulted by $\frac{1}{2}$ inch to 1 inch larger diameter of rope-pulley on the counter shaft for driving the backing-off and taking-on side-shaft. On the other hand, there is always the danger of breaking the threads over much by having too great a speed on this side-shaft.

The writer has known cases of both American and Egyptian cotton in which both better spinning and greater production have been obtained by making the top rope pulley $\frac{1}{2}$ inch to $\frac{3}{4}$ inch smaller, and thus giving reduced speeds.

The increased production has, of course, been due to fewer thread breakages—especially threads broken in backing-off or winding-on cause extra trouble in piecing-up, and sometimes break adjacent thread. For example, Sakel cotton for season 1922-3 appears to be $\frac{1}{8}$ inch shorter in some of the best varieties as used for 90's to 110's combed; and in some such cases better results have been got by the slower taking-in as above described.

Some Faults in the Yarn on reaching Weavers.

Faults in yarn are expensive, faults in woven cloth are more expensive, and faults in dyed materials are the dearest of the lot.

Manufacturers may be grumblers, but they don't like very heavy tubes sold to them as yarn, especially in fine yarns, since they don't care to pay two to three shillings per lb. for paper.

Manufacturers object to tare in skips, etc., being much heavier than stated in invoice.

Mildewed yarn sometimes reaches the weavers, being due to over-conditioning or storing in damp places, or use of certain chlorides in conditioning. Warehouses who pack yarn so very tightly in skips, put the noses of the cops to the skip sides or ends, and who use any means possible to force lids of packing skips, are no friends to the weavers and winders who get the yarn.

It may suit some people to speak very low, or to write very illegibly, but this does not suit all hearers or readers; in the same way a saving at the spinning mill is often a much enhanced loss at the weaving mill. Bad ends are to be found even in super carded yarns, twist or weft. A weaver is expected to produce good cloth, and expects to get yarn and cops in good condition. Bad ends are anathema to weavers and winders, and soft ends or slubs will often draw out thinner and force beyond almost any form of clearer. When nicked weft cops have been made, they will often knock off and make a mess in the loom. Weavers do not like long cop noses as such cops hold a less amount of yarn, and the yarn coils will come more freely off short cop noses. A concave cop nose is bad in the loom shuttle, as yarn coils will slide off and spoil the cloth. Even the best Bolton weft cops are spoiled when built with concave top cones.

Yarn is examined in weaving mill processes better than in spinning mill processes, and a good view is obtained in the creel of a slasher sizing machine.

In the loom Stockport counts of reed are the most used, and

assuming there are 120 ends of yarn per inch, it must be noted that the bars of steel in the reed rub against the six-inch lengths of yarn as many as 2,000 times in some cloths. The value of sizing warps in weaving will be very apparent from this idea.

The winder or weaver will usually find it much better to use yarn which pulls 30 lb. per lea all the time, rather than yarn which pulls 27 lb. in some leas and 35 lb. in other leas.

A closer reed does more rubbing against the yarn than a more open reed, so that 32's twist pulling 40 lb. in a 60's Stockport reed may want 50/60 lb. in a 70's reed to obtain equal results.

96's reed is common in Bolton, and may want 44 lb. pull in 40's, and would be all the better for using combed yarn.

There is a distinct relation between counts of reed and strength needed in warp yarn.

For 50's twist a table has been given as below:—

60's reed	26/27 lb. lea pull in yarn.
70's reed	28/30 „ „
80/90's reed	30/32 „ „
90/100's reed	32/34 „ „
100/110's reed . . .	36/38 „ „

70's twist—60/70's reed voile common . .	24 lb. lea.
80's twist—70/80's „ „ . . .	25 „
90's twist—80/90's „ „ . . .	27 „
100's twist—90/100's „ „ . . .	29 „

Boiling size heavily pressed into yarn intensifies the evil of soft thick ends by squeezing them out.

Snarls often extend over many adjacent threads and pull them out of position and cause floats.

A shuttle may travel at the rate of 80 miles per hour and have to be reversed over 200 to 300 times per minute.

Bolton spinners have often had complaints of steepling in the cloth, *i.e.*, an apparent regular diagonal line. This is not very likely in plain cloth, since it is then hidden by the warp.

Steepled weft in sateens has given a great deal of trouble, but has often been remedied by altering the length of mule stretch to break up in relation to the width of cloth.

Mule stretch 64 inches and cloth width 32 inches may give a chance for any faller unlocking and carriage starting out thin places to appear in regular cloth positions. 63-inch or 65-inch stretch gives a break in the regularity, or a chasing effect.

The same remark applies to mule yarn, if perchance the portions nearest the spindle point are left harder twisted than portions nearer the rollers, owing to unequal distribution of twist. Cloth width—

at any rate in sateens—should not be a measure or multiple of length of mule draw.

Assume a weaver is given 58's counts instead of 60's, the weight being as ordered, and calculations for loom requirements made on the assumption of correct counts and weights. Take 5,000 ends 100 yards long :—

$$(a)\ \frac{5000 \times 100}{840 \times 60} = 11{\cdot}11 \text{ lb. } 60\text{'s twist, say at } 2/3.$$

$$(b)\ \frac{5000 \times 100}{840 \times 58} = 11{\cdot}5 \text{ lb.}$$

= about $\frac{3}{8}$ lb. of yarn more needed for each piece of cloth to keep up to the 100 yards length.

Some dirt and defects will not bleach out in cloth.

Ring v. Mule Spinning.

In July, 1922, out of more than 132,000,000 of cotton spinning spindles in the world, there were over 76,000,000 of ring spindles, and only Great Britain possesses more mule than ring spindles, if we except the small number contained in Switzerland, which gave less than 600,000 ring spindles as against 787,000 mule spindles.

For America the figures were almost 34,000,000 of ring spindles, as against, 3,000,000 of mule spindles.

For Great Britain, in round numbers, out of a total of 56,000,000 there are over 40,000,000 of mule spindles, this being suitable for the finer counts that are spun, the greater skill of the mule spinners, the softer nature of the cloth. England has always been the chief home of the spinning mule—a very fitting thing when we remember that its invention and development belong almost exclusively to Lancashire.

Ball Bearings.

Ball bearings are finding increasing adoption in connection with cotton machinery. At the exhibition, the Hoffman and also the Skefgo people each showed a cylinder of a cop-bottom machine fitted with ball bearings.

The writer tested for himself how very easily such a cylinder could be made to revolve and how easily it would continue to revolve after once starting.

These cylinders revolve at possibly 800 r.p.m., each contains as many as 10,000 steel teeth, and a standard machine would be fitted with possibly 6 cylinders; so it is evident their easy running will be of considerable practical value.

Draftometer.

Mr. Clement Charnock, designer of Cook's roller-setting appliance, has also designed a similar sized apparatus for automatically obtaining the total roller draft in any set of draft rollers.

The appliance consists of two narrow clothed rollers—representing the back and front top-draft rollers, but only an inch or so width—which are sustained in a suitable small frame which permits of their free rotation. The framing permits a good firm hand-clasp, and registering or indicating mechanism is applied.

The method of use is somewhat as follows: A set of top-draft rollers is removed, the draftometer is firmly grasped, and its two narrow rollers held firmly upon the back and front bottom rollers. Total draft really means the relative proportion of surface speed of back roller to that of front roller, and this is what the draftometer registers.

This draftometer is a very interesting appliance, is a credit to the research work of the designer and makers, and may prove handy for simple, quick testing and ascertaining of roller draft. It by no means follows that the ordinary methods of finding draft from the wheel sizes and roller diameters will be superseded, and every well-conducted spinning firm will continue to keep a list of draft wheels on different machines for ready reference.

Natural Twist in Cotton Fibres.

Mr. Flatters, a well-known authority, says: "A few fibres taken from an unopened, but perfectly ripe cotton pod, will appear as straight, flat, ribbon-like filaments and lacking the twistings so typical of dry commercial fibre. The thinnest part of these fibres is down their central plane, from which area they are slightly thickened outwards towards their edges, which are somewhat rounded. This thickening is most definite in the oldest fibres. The moist condition of the fibres, whilst still in unopened pod, may vary in accordance with the climatic conditions of their growth; and under extremely dry conditions spiral twisting may take place even before the fibres are exposed to atmospheric action. If the fibres are straightened out whilst they are still in the moist condition and before any change in their appearance, placed on a slide under the microscope and allowed to dry slowly at the temperature of 70° F., and if during this drying process careful observations are taken of their behaviour, it will be found that the first appearance of any change taking place occurs at that particular part of the fibre from which the moisture first evaporates. The influence of this lateral contractile exertion from the central axis towards the outer edge of the fibre is the primary cause of the so-called spiral twisting of the cotton fibre."

Steel Carriages for Mules.

One of the firms now making steel carriages claims the following advantages over wood carriages:—

1. Lighter and steadier running owing to the absence of twisting and warping, the effects of which are noticeable in spindle box, tin rollers, fallers, carriage bowls, etc.
2. Copping more even from end to end of mule due to more uniform running of the spindles throughout the carriage.
3. All shafts, spindles, etc., remain on their original bearings, and are not affected by atmospherical conditions as in the wooden carriage.
4. Improvement in copping due to greater freedom in the motion of the fallers.
5. Carriage alignment improved. It has been found that the various bands do not require the same constant attention as with the wooden carriage. A considerable saving is also effected, due to the greatly reduced necessity for resetting.
6. Easier and more uniform starting after week-end or prolonged stoppages. It is also lighter in starting each day.
7. Altogether the carriage runs lighter and more smoothly, and on that account gives more production.
8. An all-steel carriage and quite fire-proof.

Casablanca's Drafting System.

The present writer was much interested in a detail on Messrs. Cook & Co's stand at the 1922 Exhibition, which consisted of sample draft rollers for a ring-frame, arranged on the Casablanca system. A short reference to this system is given on page 292 of the writer's "Intermediate Cotton Spinning," as reprinted some years ago. A frame was working with this arrangement on the continent in 1913, some of the spun yarn and descriptions being sent to the writer by Mr. John Street, an old student, who was then managing a cotton mill in that locality. The war helped to keep this Casablanca system in the background, but latterly it has received extended trials both in England and abroad. Other systems of rollers capable of large draft have also been devised such as the Gibello. The yarn sent from abroad in 1913 was 60's counts spun from 1-hank slubbing.

Briefly the Casablanca system consists of certain alterations to the rollers by means of which it is claimed that excessively large drafts can be utilised in one machine, thus enabling fewer intermediate processes to be used, as for instance spinning 60's from 1-hank slubbing and dispensing with intermediates and roving-frames. On this point the writer is aware of two or three Bolton

mills in which for years 60's yarn has been produced by using slubber and rover only without using the intermediate.

As stated, sample rollers on the Casablanca system were shown at the 1922 Exhibition.

The essential feature apparently consists in placing the top and bottom middle rollers in suitable rotating leathers which protrude forward away from the middle rollers and towards the nip of the front rollers. These leather bands act more like a pair of face-to-face endless belts. A special framing is used to hold these extended leathers which somewhat resemble the condenser rubbers of a condenser card, but on a very small scale and without side action. The extended noses of these middle leathers may approach the front rollers very closely and hold the fibres up very much better than ordinary rollers under the large draft that is used; also hold the cotton fibres in a loose manner so as not to resist drafting action.

One wonders whether in extended working there may be trouble with some of these central leathers not acting freely, and whether there may be trouble in regard to oiling and cleaning, some leathers being slacker than others.

We understand that more than one firm has several frames working, and the yarn is being made into satisfactory cloth.

One has always had to keep a keen eye on regularity of yarn in the case of large drafts on the ordinary roller system, let alone the possibility of bad spinning.

The fact that some practical men speak well of the Casablanca system after it has been before the public for ten years, and also that rival systems have come out, shows the idea to be worthy of consideration, and to be attracting considerable attention. The ordinary gearing and spindles of the Casablanca frame remain the same, and the idea is applicable to any make of frame, but presumably at a higher cost than ordinary drafting rollers. The sample rollers shown at the Exhibition represent an improvement in detail taken out in February, 1921, by F. Casablanca, of Sabadell, Barcelona, Spain, and which states as follows: "Relates to mechanism for drawing rollers in which one or more endless belts are combined." Previous attempts have been made to augment the yarn spun, and drafted. The Casablanca system of drafting has been subjected to examination and comparison at the Shirley Institute; one investigation being on 36's ring yarn from good Memphis cotton, spun on ring-frame from 1·85 intermediate counts, without using the roving-frame and giving 19½ drafted ring-frame with the Casablanca system. With ordinary rollers the same 1·85 intermediate stuff was reduced to 5-hank or counts at the roving-frame, and only needing 7·2 draft ring-frame to produce the 36's counts.

A practical man might be pardoned for concluding beforehand

that the 19½ draft of the Casablanca yarn would give a more unlevel yarn and also a weaker one.

As usual the examinations and tests of the two yarns were conducted in the most precise and scientific manner possible, and the results interested many individuals. These results were quite definitely stated as showing that the Casablanca drafting produced by a draft of 19·5 a slightly better yarn than ordinary rollers with a draft of only 7·2. The Casablanca trial gave a yarn in which the fibres spread out rather better and rather more in parallel order.

Some months ago examinations were conducted in Bolton of yarns spun under the two conditions, and the conclusions then arrived at substantially agreed with those above stated. There are mills in Bolton that have been spinning 60's yarn with only two fly-frames for years, so there is nothing new in this idea. In the present author's treatise on "Mule Spinning," Vol. II., published more than twenty years ago, the merits of setting inside the length of fibre between front and middle rollers in fine mules is very fully discussed. Scores of firms using Egyptian cotton do this because they find there are few middle iron roller laps, better drafting, fewer thin places in the yarn, and scarcely any broken fibres, because there is no weight on the top middle roller. Fifteen and sixteen total roller drafts have often been reached satisfactorily on fine mules adopting this setting. This is the same fundamental principle that rules success in the Casablanca system of drafting. Means are taken to hold up and carry the fibres better under the big draft.

1. The distance from bite of front roller to the noses of the Casablanca leathers or rubbers is only about $\frac{3}{8}$ in. or $\frac{3}{4}$ in., thus coming well under the average length of American cotton fibres and giving grand support to the fibres under drafting action.

2. The fibres are not held firmly but are supported loosely, but with reasonable firmness, and the real bite of the middle rollers themselves is outside the fibre length.

These are the principles of the small diameter middle rollers of a fine mule carried out to a fuller degree.

Unfortunately it appears to the writer that the working disadvantages of the Casablancas are great and up to the present have restricted its extent of adoption. All these leather rubbers want paying for on first application, and will probably need greater attention than ordinary rollers in regard to keeping in the best condition, freedom from making slubs, and amount of cleaning and adjustment.

In a word both the advantages and disadvantages appear very definite, and the fight for supremacy must be affected largely by these considerations.

Remembering what has been done on fine mules for many years, and what was done in waste spinning by Mr. Smith, one finds it

difficult to realise where the claim comes in for the new small diameter middle rollers of other systems. Perhaps something could be done by making the top rollers as long as the bottom ones and still using the Casablanca rubbers.

Adhesion between the rollers and the belts.—None of these systems has produced the desired result. In the present invention the bottom middle roller which drives the lower belt has its surface cut in the form of saw-teeth, so that the driving of the lower belt, and therefore of the upper belt in contact therewith, may be effected with all regularity and without slip, also without undue pressure being applied to the belts." Researches have proved the long draft yarn to be quite as good as ordinary short draft, but mill trials so far prove the Casablanca arrangements to give trouble in the mill.

About 1912 Mr. Smith, of Bolton patented a draft roller arrangement specially suited for treating short cotton fibres such as often used in condenser spinning of cotton waste. Instead of the ordinary single middle top draft roller Mr. Smith used two top rollers of very small diameter, both resting upon and driven by the bottom rollers. Mr. Smith lectured on this system at Bolton Technical School, and a number of frames were fitted up on this basis, but since then one has not heard much of it. There have been various other attempts to provide different drafting systems, such as the Gibello. F. Cesoni and A. Tirussi, Vigeano, Italy, took out a patent in June, 1920, for an altered arrangement of draft rollers. This idea related to the drawing of fibrous material on the principle of not making the fibres fast at the place of contact of the intermediate rollers of an ordinary drawing head, whereby it is made possible for the fibres to move to a certain extent one over the other. In this case the second from delivery, or the middle pair of rollers, are made of very small diameter and brought much closer than usual to the front or delivery pair, and of course it is between these two pairs of rollers that the draft mostly exists. It is claimed that a much greater drawing-out is obtained than by ordinary rollers.

Long Roller Drafts.

Attempts to diminish the number of processes in ordinary cotton spinning have been very numerous, but have not met with a great deal of success, although there are some genuine results. In the blow-room we have added bale-opening, mixing lattices, and Hopper feeders to the machines used 40 years ago, but economies have been effected by making large combinations of machines requiring only once feeding and delivery of the cotton for a total treatment equal to the use of several individual machines as formerly used.

Experience has proved it better to use the ribbon lap machine as well as the slicer lap machine in preparing laps for the comber,

and especially for laps of 14 dwt. per yard up to twice that weight. Reaching to the middle processes of cotton mills, it has been found better in most cases to use the doubling winding frame as a preliminary to the twisting machine, rather than to do both doubling and twisting on twisting machine.

At different times, individual firms have dispensed with one of the usual three processes of bobbin and fly-frames for ordinary counts and kinds of cotton yarns, somewhat larger drafts being given to the remaining machines.

The Casablanca system of drafting of recent years has started quite a number of other people along the lines of long drafts in one machine and dispensing with one process or another. The number of cotton doublings is perhaps adversely affected. The Casablanca system has proved it to be quite possible to use a very large roller draft, but there are troubles in keeping the parts clean and in perfect working order.

In any new system of roller drafting, apart from the question of cleaning difficulties, regard must be had to possible first cost, yarn breakages, extra waste, lower speeds of machines, greater cost, lower quality of yarn.

Spun under good conditions, yarns produced on the Casablanca have been tested by excellent investigators and reported as being very good, but the value of such reports would be increased if the investigators watched the frames working for 3 months under ordinary mill conditions. The small leather rubbers require some attention as being difficult to control. The "break" draft between back and middle rollers in the ordinary 3-pair system is almost always very small and simply designed to prepare the roving for the real drafting between the front and middle rollers and to give a better fibre control to the middle rollers.

Drafts of 15 or more have often been used on fine mules with good staple cotton, light top middle roller, and setting inside the fibre length between front and middle rollers.

Any roller settings and draftings must be influenced by the fact that fibre lengths vary.

Increased twist per inch, longer cotton staple, harder cotton, thicker rovings, require wider setting front and middle than the opposite conditions, especially with weighted top middle rollers.

While the Casablanca system has been based on leather rubbers possessing good fibre-carrying ability, but somewhat costly, such system as the Cellini and the Jannink have depended more upon using a small top middle roller and bringing the middle rollers as close as possible to the front line.

It has been stated that the Jannink system claims to obtain a high draft by setting the middle top nip nearer to the front than the average fibre length, weighting the middle top roller lightly to permit

fibres to slip beneath, and using suitable gearing to obtain the desired effect.

Draft Wheel Arrangements.

Since Arkwright's time many attempts have been made to supersede the ordinary 4-draft wheel arrangement for other systems designed to give better facilities in altering drafts and changing wheels.

At the 1914 Manchester Textile Machinery Exhibition the writer inspected with great interest a stand containing a new drafting arrangement by Mr. Battersby, a former student of the writer's. It was designed to give a wider range of change and a more exact one, especially on self-acting mules. The writer devised and applied to actual work a drafting arrangement worm and worm-wheel gearing for draw-frames containing 4 or 5 pairs of draft rollers. The above two arrangements are typical of a good deal of effort, and much could be said about both. The salient feature is that neither these nor other methods have had much luck in dispossessing the ordinary four drafts as used fundamentally for more than 100 years.

Successful improvement in draft wheels has followed more on the lines referred to below.

The most important feature has consisted in the introduction of cut wheels of finer pitch than the former cast wheels. Instead of cast wheels of 8's to 12's diametral pitch we now have cut wheels of 14's to 18's pitch, thus enabling strong durable wheels of larger pitch and many more teeth to supersede the former ones. The wheels are lighter to carry about, the drafting action is more accurate, there are fewer wheel breakages, and drafts are more finely adjusted.

A second very important feature in modern draft wheel arrangements consists in developing the crown wheel as a change wheel, thus making it possible to alter any one of the four draft wheels, *i.e.*, either the back roller wheel, the crown wheel, the ordinary driving change pinion, or the front roller pinion, the latter only when it is made double, unless at great trouble.

The reconstruction of the crown wheel carrier in the draft wheels of spinning mules enables this wheel to be just as easily changed as the driving change pinion.

We get the double advantage of a fine adjustment by one tooth in the large crown wheel, meaning a less effect than one tooth in the change pinion. At least one firm has taken advantage of this principle, and of the stronger modern cut wheels, to reduce the number of teeth in both driving change pinion and crown wheel, thus reducing the crown wheel to a convenient size, and also bringing the crown wheel centre more above the *back* roller centre. The author has seen much trouble caused by using a very large crown wheel, and having a distinct lifting effect due to the wrong relative

positions of back roller wheel and crown wheel, but this is remedied by using a set of small wheels. For years we have advocated large change pinions to get a fine change, but, by making the crown wheel as the standard change position, it is no longer necessary to use large driving pinions. We also have the natural law of a larger crown wheel being used for larger or finer counts.—

A typical arrangement under this head would be to have 25 change pinion driving an 80's crown wheel, back roller wheel 54, and front roller pinion 18, so that these two latter represent a draft of three of themselves. Cut wheels permit this.

Such a combination enables drafts to be altered from 12 down to 8 without touching back roller wheel or front roller pinion. By the provision of a double-eared bracket for carrying the driving change pinion and the driven crown wheel, a very firm bearing is obtained for these wheels, and one easily adjusted when changing drafts and yarn counts. A change crown wheel of 78 to 82 teeth enables a change of less than one count in 60's, and we are lucky if we can get to one count and maintain it. Larger alterations in counts could be met by more than one tooth on this wheel, or else by altering one of the others.

A system that has been advocated—but is not very easy to maintain—is to have the crown wheel exactly the same size as the counts, *i.e.*, 70's wheel for 70's counts, 75's wheel for 75's counts, and so on for the range.

Double Change Wheels.

In draft changes, and, in fact, change wheels for any purpose, such as twist per inch or gain of carriage, the finest and most exact changes ever required may be obtained by altering both a driving and also a companion driven wheel in same train of wheels.

Example.—One tooth in a driving 40's wheel was altered, and then also one tooth in a 60's driven wheel to give the opposite effect; it is clear that about two-thirds of the first alteration will have been neutralised by the second change.

Distribution of Twist in Mule Yarns.

Tests showing more twist in yarn nearest spindle point :—Test made December, 1922, at Bolton School. Two ends of 20's put through front roller only. 67 inches wound on per draw. 64 inches travel about 3½ inches roller motion. Average about 17·63 turns per inch.

1st section from spindle point,	6·64	per cent	above average
2nd „ „ „	4·37	„	„
3rd „ „ „	2·10	„	„
The section on spindle blade,	1·53	„	„

This is tested again in $1\frac{1}{2}$ inch lengths below :—

17·5	15·0	15·5	17·0	21·0		20·5	21·5	25·0	20·0	18·0
17·5	15·5	19·0	15·5	19·5		28·0	21·5	21·0	25·0	17·5
20·5	23·5	18·0	20·0	17·0		22·5	18·0	21·5	16·0	13·5
24·0	21·0	18·0	22·0	18·5		21·5	23·0	25·0	23·5	24·0
18·5	20·0	15·0	18·5	19·0		23·0	21·5	17·0	20·0	17·0
18·0	15·0	20·0	23·0	22·0		27·0	23·5	20·0	21·0	16·5
18·0	19·0	20·0	22·0	20·0		23·0	18·5	17·0	18·0	19·0
18·0	17·0	22·0	20·0	29·0		17·0	21·0	21·0	20·0	19·0
18·0	15·0	19·0	19·0	25·0		20·5	19·5	20·0	19·0	20·0
18·9	17·8	18·5	19·6	21·2	Coil	22·5	20·9	20·8	20·2	18·4
·3	·3	·3	·4	·4	Twist	·5	·6	·8	1·0	·8
18·6	17·5	18·2	19·2	20·8		22·0	20·3	20·0	19·2	17·6
		18·9						19·8		

15·0	22·0	17·5	20·0	19·0		22·5	22·0	20·0	20·0	17·5
19·3	20·9	20·3	22·5	20·0		22·3	20·4	17·0	18·9	17·2
16·0	14·0	17·0	25·0	24·4		26·0	17·0	17·4	16·4	19·0
21·0	16·9	17·9	16·3	19·8		21·9	18·3	19·5	15·5	14·0
16·6	16·0	20·0	20·3	21·3		18·1	20·5	17·0	18·9	14·0
16·0	15·6	15·0	21·5	20·6		20·6	22·4	16·8	21·5	20·5
18·9	15·6	16·0	18·4	15·0		18·0	18·7	19·3	21·9	19·0
17·4	19·0	22·0	13·0	22·3		19·0	17·4	17·7	21·6	20·0
21·4	17·8	18·0	20·0	18·0		17·0	20·4	21·9	16·7	17·3
17·1	19·0	21·5	18·3	15·0		23·4	23·0	21·9	20·0	17·2
17·9	17·7	18·5	19·5	19·5	Coil	20·9	20·0	18·8	19·1	17·6
·3	·3	·3	·4	·4	Twist	·5	·6	·8	1·0	·8
17·6	17·4	18·2	19·1	19·1		20·4	19·4	18·0	18·1	16·8

	18·3		18·6
1st Cop	18·9	1st Cop	19·8
Average	18·6	Average	19·2
6·7 inch sections	18·8	6·7 inch sections	17·8

The average of 1-inch tests gives ·6 more than the 6-inch tests, of this amount; about ·3 is caused by the jaw of twist tester being about three per cent. further away than the 1 inch distance it was supposed to be set at. This was noticed when 1st cop had been tested, and the 2nd cop was tested on the new twist tests.

N.B.—The apparatus used prevented these tests from being as exact as desired.

Golland's Cross Winding Motion for Spinning Mules.

At the 1922 Manchester Exhibition a good deal of interest was manifested by spinners and weavers in this small exhibit of a few feet of faller shaft, and the extra crossing wire along with the winding wire.

Briefly, this device purports to be an application to the fallers of a spinning mule, by which the cotton threads are moved along the "chase" or cone of the cops three or four times during each run-in of the carriage.

Cross-winding of yarn upon cops for subsequent unwinding is the fundamental method of obtaining cops that will "ready" and be free from halching and consequent waste.

It is quite an old idea to use a switch-back copping rail and move the winding wire up and down the cop "chase" to obtain cross-winding. Such methods have only met with a moderate amount of success for comparatively coarse yarns owing to complications, breakage of threads during winding-on, and extra overlooking needed to keep the parts in good order.

Re-winding of weft yarn on such weft winding frames as Leeson's, Stubbs', and Schwerter's is done on the quick or cross-winding principle, and hard non-wasteful cops are thus obtained which greatly facilitate the work of many looms; two to four cops into one.

Golland's method of obtaining cross-wound cops directly on the spinning mule is certainly very ingenious and possesses very novel features. How far the addition of a score or so of finely cut wheel combinations in the length of the fallers of one mule, and the use of a third faller wire, will affect the ordinary work of spinners and overlookers remains to be seen.

It is at least claimed for the arrangement that it is entirely automatic in action, and requires no extra attention from those in charge. Demonstrations of how cops built on this system could be maltreated and yet ready without making waste were frequently given at the exhibition.

A third faller wire is employed, placed between the winding faller wire and the spindles and beneath the yarn.

A small combination of finely cut wheels and racks links this extra wire with the winding faller shaft, and thus gives the requisite control, and this combination is repeated a score or so of times in the length of the mule. The wire is carried by fingers, which move the wire up and down as required to obtain the cross wind—say possibly four times for each run-in. The extent of movement of the crossing wire may be varied to suit the length of chase or top cone, the travel being obviously less during the formation of the cop bottom than it is when the full length of top cone of cop has been obtained.

Any suitable number of sickles are used for the crossing wire, as for the ordinary wires the extra sickles being mounted loosely upon the winding faller shafts.

The writer has been interrogated on this apparatus by various people, and there is no doubt of the value of cross-winding, but one wonders, among other things, in regard to the extra first cost, the trouble of maintaining in satisfactory working condition, and the effect on the spinning and piecing up.

Ring-Spinning.

In the ring-frame the bobbin is fast to the spindle, and the thread draws the traveller round the ring.

In the flyer throstle the bobbin is loose on the spindle, and is dragged round the spindle by thread.

The ring-frame first became more or less used in America, and its progress was soon noted by Mr. Blakey, of the firm which later became Brooks & Doxey. This firm, and also Messrs Howard & Bullough, quickly placed the ring-frame before their customers. The early history is somewhat obscure, but it is said to have been invented by Mr. Jencks, of Rhode Island.

Since then ring-spinning has attained its great position by sheer simplicity, aided by repeated improvements in detail, such as the spindles, bobbins, rings, travellers, inclined roller stands, thread-boards, creels, and copping motions.

In 1874 Mr. Rabbeth, of Pawtucket, R.I., invented the self-contained spindle, with bolster and footstep all inside, movable as one piece.

When a ring-frame is driven by a direct-coupled motor, the coupling may be made through a centrifugal clutch, which enables the motor to be started light and to take up the load gradually. Alternating three-phase motors are in general use, and there are some who contend that the gradual start-up is very essential to prevent many broken threads at setting-on. This is scarcely the author's experience, and there are some who contend for an almost full-speed direct start to prevent snarls running in the yarn.

It is quite possible to have variable speed driving by which the building motion causes the speed to be greater when winding near the base of the cop cone than at or near the apex.

Machine moulded cast gearing wheels are stated to be more durable than cut teeth, although some prefer the latter.

Gearing wheels—not draft wheels—may be $1\frac{1}{4}$ inch wide, 11's pitch, and kept below a surface speed of 340 yards per minute pitch line.

Tape driving of spindles has received a fair amount of acceptance for ring-doubling frames, but not much for ring-spinning.

In tape spindle driving only one tin roller is used, the right-hand or left-hand tin roller as deemed best. It is customary to drive four spindles with one tape, and to maintain sufficient tape tension by means of a weighted jockey pulley.

Occasionally rope driving is used for ring-spinning or doubling frames, and a rope speed of practically 4,000 feet per minute is possible. Diameters of tin rollers vary from 7 to 11 inches, and speeds reach over 800 r.p.m., and these rollers must be kept well balanced. For actual spinning, while spindle speeds of the flexible Rabbeth type are usually within the limits of 8,000 to 11,000, a speed of 13,000 r.p.m. has been attained.

Modern ring-spindles are of the most elaborate character of any used in the cotton trade, and each spindle may contain 9 or 10 component parts. Grinding machines are much used in making the spindles, the spindle blade being hardened and tempered, and afterwards ground all over to fine gauges.

The "cigars," or inner tubes of the spindles, may be constructed of cast iron of a special kind and machined by automatic appliances. Drop-forging hammers may be used to forge the rings, or else rings may be made by forging machines from solid steel bars without weld. Each ring is machined all over by automatic machinery and is case-hardened.

Mule Spindles.

A mule spindle is a plain simple article to look at, but there is really a great deal to it. When it is made correctly it needs to be put at the correct level, the correct distance below the rollers and from the rollers, correct in relation to the spindle band and tin roller, and must have both bolster and footstep bearings well attended to.

Mr. Hardman has given the following list of operations a spindle may go through before finishing. "Forging, rough centring, rough stretching, grinding, glazing, intermediate centring, finish grinding, intermediate stretching, finish centring, wharving, polishing, final stretching, testing and examining."

A test of 10,000 r.p.m. must show no vibration.

Very little variations in diameter at almost any point in its length, from gauges, will reject a spindle.

The most precise grinding is required for each spindle. Mr. Hardman gives the following diameters of spindle points: 35's gauge for 40's yarn, 43's gauge for 60's yarn, 43's/47's gauge for 70's/100's yarn, 46's/49's gauge for 100's/150's yarn, 48's, 50's gauge for 150's/300's yarn.

Also the following table of spindle bevels:—

$4\frac{3}{4}$ inches bevel for 30's/40's yarn with 17 inch spindle.
$5\frac{1}{4}$ „ „ „ 50's/60's „ „ 17 „ „
$5\frac{1}{2}$ „ „ „ 80's/100's „ „ $16\frac{1}{2}$ „ „
$5\frac{3}{4}$ „ „ „ 120's/150's „ „ $15\frac{1}{2}$ „ „
$6\frac{1}{2}$ „ „ „ 200's or finer „ „ $15\frac{1}{2}$ „ „
For soft weft yarns $\frac{1}{4}$ inch additional in each case.

Halliwell Yarn Conditioner.

Yarn conditioning by mechanical means appears likely to almost entirely supersede cellar conditioning, which requires days to do the work, takes up considerable space, and requires care in handling the skips of yarn so as not to mix the sorts. The two-fold cop packing required for cloth or blanket conditioning is neither good for the cops nor very economical.

Yarn in cop, cone, cheese, or ring-bobbin, or other form, may be treated as coming direct from the winding or spinning room. The skips or other receptacles for the cops are placed—possibly in groups

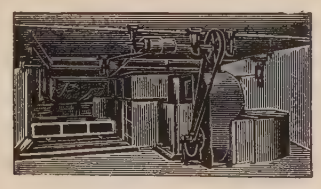


Fig. 174.—Halliwell's Yarn Conditioner.

of six—in hollow wagons, formed with the correct number of openings to receive the skips to about one-half their depth. The full wagons are run into chambers of which there may be three to a machine. Connected with these chambers are inlet and outlet ducts, the extreme ends of which join a casing containing a powerful fan which acts both as a blower and an exhauster in circulating the air through the chambers. Before entering the chambers the blast of air created by the fan encounters what the maker terms an "atomizer," which receives and breaks up heated water supplied by an injective, and in this way provides the moisture required to condition the yarn.

The chambers having been closed and the connections made, the action of the fan forces the moistened air into the chamber, in the form of a spray, and at the same time draws the moistened air through the yarn. The cops retain the moisture but allow the air to escape.

"Outsiders'" Cottons.

During the year 1922 especially, and in 1923 also, the more usual styles of American cotton became very dear in spite of the

deplorable state of the British cotton trade, and the fact that Russia and some other countries were taking little cotton. Reduced acreage under cotton, increased raw cotton requirements in America itself, the depredations of the Ball-weevil, efforts of speculators and manipulators on the markets, and the determination of American holders to maintain good prices were most probable causes of the high price of American cotton. At the same time greater and more prolonged financial losses were being sustained by English cotton spinning mills than at any previous time, most of them for many months having to sell yarn at a serious loss. American cotton for 38's twist came within a fraction of the price of 60's twist Egyptian.

These facts have helped to direct the attention of many spinners to what have been termed "outsiders," or cottons not regularly included in market quotations. For example, it was found at one time that "Tangius" Peruvian was 1d. cheaper than Memphis, although distinctly better in staple. A good deal of the "rough" Peruvian, suitable chiefly for mixing with wool, is giving way to moderate rough good for 50's/60's cotton yarns.

Boweds of 1 inch to $1\frac{1}{16}$ inch staple became 50 points dearer and some Royton and other spinners have found a substitute in what are termed "Indian Americans" or cotton grown in India from American seed, and which is less deep in colour than average Indians, and was quoted at 300 points off. Assume an equal mixture of American and Indian seed at 13d. (January, 1923), with boweds at 16·5, the price per lb. was $14\frac{3}{4}$d. for the mixing as against $16\frac{1}{2}$d. for all boweds.

Persian cotton is another "outsider" that attracted buyers for low counts or for mixtures, although a poor type of cotton generally.

The art of cotton blending has received more attention and has been more the subject of experiment during the last few months than at any previous time from spinners of American cotton.

It would appear that Liverpool has been losing its supremacy somewhat as the chief arbiter and controller of prices of American cotton.

Memphis cotton for 38's twist has been quoted at the same price as a moderate quality of Egyptian sakel for 60's twist, say $17\frac{1}{4}$d., recently.

Liverpool "jobbers" have not been having a good time in their efforts to keep American cotton prices down.

It has been found that some mills having a surplus of carding capacity have been able to purchase "outsiders" and lower grades of cotton, and come off very well by getting less weights from the cards. When cotton for 38's twist could be obtained in good quantity and quality at moderate prices many firms went in for few cards and heavy production, but some of these firms are now getting extra cards. Wages for carding engine operations never add much to production costs. This idea of better carding is fostered by the

tendency of America to keep the better grades and send us the lower ones.

There are many spinners who now think it will be a good thing when the levy of 6d. per bale for American and 9d. per bale for Egyptian shall become compulsory, and thus help the work of the British Cotton Growing Corporation as well as that of the British Cotton Growing Association. Instead of "Memphis" for 44's some spinners are using smooth Peruvian, and instead of points on Texas for 38's white Brazils are coming into use.

"Monte Christo" West Indian has been used by some for 32's to 36's twist. What is termed "Argon" cotton is yet another "outsider" asked for.

Both East and West Africa have furnished examples of cotton coming within this market expression of "outsiders."

One penny per head for the workers is a suggestion going along with the 6d. per bale from the employers.

The Empire Cotton Growing Corporation got its Charter in 1921, but the 6d. per bale has hitherto only been paid by somewhat more than half of the spinning firms.

On Manchester Exchange, on June 12, 1923, Egyptian 36's was quoted 1d per lb cheaper than American 36's and guaranteed to be much better. One month later Egyptian cotton for 76's was bought at same price as American for 36's.

Yarn Testing.

Despite the criticisms of adverse theorists and others, lea testing of cotton yarns retains its hold on the spinning trade.

The great body of spinners—many of whom have got single thread testers and are ready to use them as needs be—find they can sell their yarns and depend on the results better and more conveniently from lea tests than single thread tests. Users of yarn, however, may lean towards single thread testing, since yarns are used as individual units. General analysis and comparisons with other equivalent yarns form the usual practical method of gauging quality, as well as by reference to previously ascertained tables.

Tension devices for the yarn under a wrapping test are occasionally used, possible thread breakage or pressure of the hand on the yarn affecting one's judgment of tension. Standard wrapping speeds should be adopted as nearly as possible.

Grain and decimal grain weighing of yarn has become pretty general, variations only being expected within moderate limits (scales will test up to $\frac{1}{10}$ grain), although this depends on the counts, length tested, and general quality. The grain and decimal system is convenient for reference tables made out to tenths of a grain. Ordinary plain chemical balances kept in a glass-fronted case are preferred by many users, but there are special yarn scales such as Knowles, the Brown & Sharp, and others.

Delivery of coarse counts of yarn, but correct weight ordered means that the purchaser obtains a much shorter length of yarn than if correct counts. Calculations *ad lib.* may be made to show this.

It is sometimes required—more especially by weaving costing clerks and such like—to test the counts of small pieces of yarn taken from small pieces of cloth. Various special small yarn testers are available for this purpose, although some yet place reliance on the old method of getting a few threads of known and similar counts, and as many threads of the unknown, the threads being put together, crossed and well twisted so that an expert can form a moderately correct conclusion of the unknown counts by examination, feel, and general effect.

An important firm of Bolton spinners bought a single thread tester near the end of 1922, and shortly wrote the makers asking how they could compare the results of single thread *v.* lea testing. The reply was that there could be no comparison, since lea testing was utterly wrong in every way. Although this was a ridiculous answer, the question has been often asked and is not very easy to answer with real satisfaction. A lea of yarn placed upon the lea tester represents 80 double threads, and in making any sort of comparison it is perhaps best to take individual double threads on the single thread tester. A double thread of 54 inches or one wrap equals 2 single threads of 27 inches each, and in any comparisons the nearer the individual double thread test can be got to these measurements the better. It might be argued in this way: if an individual doubled thread broke at 8 ounces, what should a lea of 80 doubled threads break at? Obviously the answer would be 40 lb. This does not work out in actual testing, or at any rate such is the Author's experience after making very many observations.

A different procedure is to make many tests of either individual single or individual double threads and covering several standard counts and qualities of yarns. At the same time make a sufficient number of lea tests of the same yarns, and by calculations and comparisons establish a kind of numerator or coefficient between the two methods.

Single thread testing—as might be expected—always shows a greater variation in results than lea testing, because of one thread more or less helping another in lea testing. Ten per cent. is frequent enough variation in lea testing and more than double that from individual threads.

One double thread to a lea or 80 double threads = 1 : 80.
One single „ „ „ „ = 1 : 160.

In making any kind of comparison—and it is quite a nice little exercise in research to do this—something depends on the make of

single thread tester used, the good condition of the machines, the precision of the operator, the length of thread taken. In one case it was stated that if a lea test represented 100, the single thread test might represent ·9, which is an arbitrary standard neither represented by 1 : 160 nor 1 : 80 but is given as the result of actual testings. Certain tests of 160 single threads added together came to a distinctly greater total than the full lea tests of same yarns.

Twist tests of single yarn are often made in one inch length with magnifying glass and only one end, the yarn being turned. In other cases from 1 to 2 inches of single yarn may be taken and untwisted from both ends at once.

Uniformity in twisting should be noted equally with amount of twist.

In oven testing for moisture it was formerly laid down that possibly 90 minutes should be the test duration. Later on with improved ovens and greater heating the duration was put down 40 or 45 minutes.

The more up-to-date method is to leave the yarn or cotton in the oven until it practically ceases to lose weight. For best conditions the ventilation, relative humidity, and temperature of the testing room should be well regulated, but these atmospherical conditions are often taken little notice of.

Good scales are required with the weight pan and beam outside the heated cylinder, but the cotton pan inside, a sample of possibly ½ lb. brought in air-tight vessel placed inside the oven and carefully weighed, weight adjusted to balance as the heat expels the moisture. When weight loss has ceased to register, the difference in first final weights is noted. Allowance is made for the natural moisture or 8½ regain (not loss on 100), and possible excess moisture is readily found.

Regularity in Cotton Yarn.

On Saturday, March 10, 1923, the author attended a greatly appreciated lecture by Dr. Oxley, of the Shirley Institute.

One feature consisted of a description—aided by lantern slides—of a method of measuring the regularity of twist hardness by a photographic method, the yarn being subjected to lateral compression. The most outstanding feature resulting from the use of the instrument and methods described, was to show clearly and definitely that there is a considerable hardness and excess of twist—over the mean or average per inch—in the portion of yarn nearest the spindle point. There is the assumption that this portion of yarn will contain most twist because it is nearest the spindle, and having plenty of twist itself tends to give twist to the portions of yarn nearer the rollers. Mr. Fullard who recently conducted experiments on this matter—

with the aid of the writer at the Bolton Technical School—was disposed to contend that some of the extra twist also passed to a short length of yarn wrapped round the spindle.

There was discussion around the question of how far the yarn delivered by the winding roller delivery motion was affected by this question of that yarn nearest the spindle tip being finally left with much more than its share of twist. Assuming 3 to 3½ inches of yarn delivered during the run in of carriage, this yarn is not wound on the same draw, but is left for the next draw between roller nip and spindle, so that the twist of this later draw runs through this yarn more or less.

In this respect of having a high twist peak for the yarn nearest the spindle, mule yarn would appear to be worse off than ring yarn, but other slides shewed that ring yarn varied more than mule yarn for the greater part of its length. In fine numbers especially the qualities of ratch and gain help to give regularity on the mule.

There was also described a new method of testing the strength and regularity of ring and mule yarns by subjecting short lengths to oscillating stresses, and using for this purpose a newly designed scientific machine.

This mechanical method of testing yarns gave results much similar to those obtained by the photographic method, and especially in regard to excess strength of mule yarns in short lengths coming often near the spindle tip, while ring yarn shows no such periodicity. In using the oscillating stress machine the mule cop or ring bobbin was taken and 3¼-inch lengths carefully cut off the yarn and attached to the grips, the distance of 2¾ inches wide coming between the grips. The motor being started the threads are subjected to various stresses which have more or less resemblance to some given in weaving. Breakage of a thread stops the machine and a revolution counter gives measure of the strength of the piece of yarn under test.

The machine is easily and quickly restarted. These testings of yarn by means of oscillating stresses and also by the photographic method, are very ingenious and reflect great credit upon Dr. Oxley and the other gentlemen associated with him in these experiments.

It has been suggested that the excess twist and strength in the short portions of mule yarn nearest the spindle points, might produce a bad effect in doubled yarns by two of these harder places in different yarns frequently coming together in the doubled yarn.

Possible suggested remedies have been the doubling together of two yarns spun with different stretch lengths.

Instead of this pains might be taken to separate the periodical hard places in the two yarns at first, and one being possibly half-way of the other, the two would probably not come together. Again, one wonders whether the trouble involved in the doubling process in carrying out these suggestions, would not be very much greater than the benefit received.

There are, of course, many other points to watch and attend to in actual mill working, besides this particular one of extra hardness in mule yarn nearest the spindle point.

It has been argued that existing methods of testing or judging yarns for regularity are not sufficiently searching and scarcely accurate enough. Judgment of regularity by winding yarn on a black cardboard or even a blackened cylinder, taken along with lea or half lea testings for counts have been prevailing methods for a long time, possibly checked by strength tests.

The photographic method deals with yarn in shorter lengths and judges yarn regularity by a more scientific method. Irregularities may be magnified thousands of times and tests made quickly over a good length of yarn, the magnification amount exceeding that given by a high-power microscope.

"Sorters" for Cotton Hairs or Fibres.

The Balls sorter and the Baer sorter are two very different instruments devised within the last few years for mechanical aiding in the sorting and distribution of cotton fibres from given samples of cotton. In this country, at any rate, the Baer is the more recently introduced, and it has been introduced by the makers of the Baer single thread tester for strength of yarns. The fundamental feature of the Baer sorter consists of a series of parallel combs which give definite assistance in sorting cotton fibres or hairs according to length. Part of the work consists in laying the fibres in order of decreasing length upon black plush with one end always on a common straight base line, so that the opposite ends form a curve which shows the distribution of fibre length and proportions of fibres for different lengths. A frequency curve showing length features may then be conveniently made.

Dr. Ball's sledge-sorter contains essentially different features and arrives at much the same results by other means.

Speed of Ring or Lifter Rail.

Doubling Frame.

Tin roller revolutions per minute 700. A 40's tin roller wheel in a case of a single tin roller drives a 100 twist wheel carrier. Bottom twist wheel 40 driving a 60 top twist carrier of 60 teeth, there being a large single carrier of 120 teeth interposed between these. A top twist wheel of 36 teeth drives a delivery roller wheel means a complete up and down movement of lifter rail. Single tin of 70 teeth. Bottom delivery roller $1\frac{3}{4}$ inches diameter. On this roller is a double worm driving a 15 worm wheel on top of inclined copping shaft, and on lower end of inclined shaft is a second double

worm driving a worm wheel of 70 teeth, which carries the heart cam on same short shaft. Every complete revolution of this cam means a complete up and down movement of lifter rail. Single tin roller of 8 inches diameter, 4-inch lift.

1. $\frac{700 \times 40 \times 40 \times 36}{100 \times 60 \times 70} = 96$ r.p.m. of $1\frac{3}{4}$ inch roller.

2. $\frac{96 \times 7 \times 22}{4 \times 7} = 528$ inches per minute delivered.

3. $\frac{96 \times 2 \times 2}{15 \times 70} = \frac{1}{5}\frac{9}{2}\frac{2}{5}$ number of double lifter traverses per minute.

4. $528 \div \frac{1}{5}\frac{9}{2}\frac{2}{5} = 528 \times \frac{5}{1}\frac{2}{9}\frac{5}{2} = 1{,}443\frac{7}{4}$ inches wound on during one complete up and down traverse of lifter.

It may be noted that an alteration of either the top or the bottom twist wheel would not only drive the expression rollers at a different speed, but would also proportionately alter the speed of the lifter, and in this way the two would be kept in correct proportion so long as the thickness of material remained the same. If the thickness of cotton were altered without corresponding alterations in twist wheel, then the worm or worm wheel connections of copping motion could be altered.

Ring Frame Speeds.

In connection with speed calculations for the ring frame it will be interesting to notice the statements of an eminent firm of ring frame makers on this point. It is recommended that the mill shaft run at 300 to 350 r.p.m., with a drum 30 inches diameter, 5 inches wide, driving a pulley on the frame of 12 inches diameter $3\frac{3}{4}$ inches wide for a $3\frac{1}{2}$-inch belt for 300 spindles, 4 inches wide with $3\frac{3}{4}$-inch belt for 400 spindles, $4\frac{1}{4}$ inches wide 4-inch belt for above 400 spindles. Thus with a 10 inches diameter of tin roller and $\frac{7}{8}$ inch diameter of spindle wharve we obtain a constant of 80 to 87, and the calculated spindle speed divided by this constant equals the calculated r.p.m. of the driving pulley on the frame. Example:—

Spindle speeds	10,000	9,500	9,000	8,000
Revolutions of frame pulley per minute with 10-inch tin roller and $\frac{7}{8}$-inch special spindle wharve . .	865	830	790	700

In the same way with spindle speeds of 7,000 and 6,000 we obtain respectively 615 and 524 revolutions of frame pulley. It must be noted that as in the case of the rim shaft fast and loose pulleys on a mule, the possible diameters of frame end pulleys on a ring frame are somewhat limited, although it is possible to reach 16 inches, or 17 inches, whereas 12 inches is about the usual diameter.

The Spindle and Spindle Bands.

The spindle of a ring frame is a wonderful piece of mechanism, the result of above sixty years of special experiment and development. The spindles of a mule or ring frame are made in larger number, and are actually revolved at higher speeds than almost anything else in the way of rotary mechanism. The spindle of a mule is simple, but that of a ring frame is quite complex, and it is wonderful how it will continuously work at very high speeds and often with more or less unbalanced bobbins. It is now invariably self-contained or, in other words, the bolster and footstep constitute practically one long bearing complete with spindle, so that all the parts are adjusted at one operation. A complete ring frame spindle may be said to contain the following parts : the spindle itself with its wharve and sleeve, the spindle holder to prevent the spindle from lifting away when a bobbin is plucked off the spindle, the inner tube in which the spindle is accurately fitted, and the combined bolster and footstep which is screwed fast to the spindle rail. The separate footstep and bolster of the mule spindle are utterly unable to meet the conditions imposed on a ring spindle by the carrying of the comparatively heavy bobbin. Well-made spindles will now revolve steadily at any speed desired in the mill so long as there is not excessive breakage of the threads. This is in spite of the unsatisfactory nature of the load imposed on the spindle by the yarn and the bobbin by pulling the traveller round the ring by the resistance of the air to the yarn and traveller by uneven distribution of load, by variation in the centre of gravity, and by the pull of the spindle band, especially if the latter is very tight. The pull of spindle bands varies a very great deal in extent, going from possibly less than a $\frac{1}{2}$ lb. in the case of a very slack band up to 7 or 8 lb. in a very light band. Something like $2\frac{1}{2}$ to $3\frac{1}{2}$ lb. is perhaps a fair average working pull in a modern spindle. Variable pull of spindle bands is often a source of much trouble in ring frames, and especially if there are great atmospherical changes or they happen to become saturated with oil thrown off the spindle bearings or the tin roller bearings. Changing from dry to wet weather will tend to contract the bands unless a room is evenly humidified, and tend to increase the power required to drive the spindles very considerably. The same effect may be produced first thing in the morning, especially if the rooms have not been well steamed during the night time.

Slack bands cause variation and loss in twist, while excessively tight spindle bands add to cost in driving and renewal of bands.

Scouring.

"Scouring" takes place periodically for all frames containing draft rollers. Every three months, six months, or twelve months

are periods adopted for different machines or by different firms. Rollers are unweighted, and all top rollers and clearers removed so that a most thorough cleaning may be done of all parts belonging to the rollers.

The custom of uncoupling all the bottom steel rollers at the "spigot" joints is much less frequent than formerly, since it does harm to the flutes and the couplings, although permitting rather more thorough cleaning.

Middle steel roller necks should be tallowed. Damaged rollers may be treated with card fillet or pumice stone. Broken parts should be now repaired. Periodical "scouring" is essential for good clean work.

Crackers. Other items.

In the most technical sense "crackers" are chiefly caused at the ring-frame when spinning Egyptian cotton on rollers made and set for American cotton. Front and middle rollers both gripping long fibres together have caused short fibres to issue over-much in places and to twist round the longer fibres, or make a kind of small pin-head snarl. When the yarn is pulled these may pull out or snap with a slight crack, and hence the term. Wider set rollers, rollers covered or varnished better, may stop "crackers" under such conditions.

"Crackers" may result from mixing long and short fibres together and short fibres bunching round long ones. These places in mule yarn are sometimes termed crackers.

An arrangement explained by Mr. Holt to the present writer has led to developments in the use of horse-hair for the linings of coats and other garments.

The horse-hair is in various lengths, and of itself difficult to cut and use in regular proportions and lengths without making excessive waste.

The arrangement consists in assembling the horse-hair in a cone cup having a very small aperture at the bottom only permitting a very limited amount of hair to pass at one time. This is immediately twisted in with a cotton thread, so as to produce a continuous length of mixed semi-horse-hair yarn, which can be cut up or doubled up just as required, and forms a much more suitable packing or lining to such materials as coats.

In yarn testing it is vastly important that the testing machines, weights, and other parts be kept in the highest state of accuracy.

For getting the best cone belts of fly-frames one method is as follows:—Regularly obtain belting of suitable quality and diameter in long lengths. Work this for the main driving of fly-frames for a month or so, even if rather narrow. Cemented belting should be be used. Store this belting in a proper place, and cut cone belt lengths off as required. Cement piecings are best, even when putting the cone belt on the frame.

A cement for belt piecings has been recommended as follows:— Cover a quantity of isinglass with acetic acid and let it stand for possibly a day, the mixture becoming very soluble but rather thick than watery.

The two ends of a belt may be held in clamps, the cement applied, the piecing clamped in position and left for ten or a dozen hours.

Clearing.

Clearer guides can be set to stop small neps, snarls, and bad ends, and yet not be able to stop straight soft ends, which give way and squeeze through the guides.

In an example of 500 lb. of yarn, apparently very well cleared, the warper found over 60 bad ends due to this cause.

Sometimes warpers are paid so much per dozen for bad ends picked out. Black ends, slack ends, and short lengths of three-fold helped to make up the number.

Novelty Yarns.

Spiral effects are possible in many ways, some of which are referred to below:—

(*a*) There may be two single yarns of which one is twist way and the other is weft way, so that these two being twisted together the double twist will be opposite to one of the single threads whether the doubling be twist way or weft way. The single that is untwisted by the doubling process will be slacker than the one that is extra twisted, and the slack one will tend to give a spiral round the tight single yarn, used in some woven goods for either warp or weft.

(*b*) A mild spiral is very easily produced by simply twisting together two single yarns of different counts but of similar twist direction, the effect being increased within limits by the extent of counts difference.

(*c*) Greater and more expensive effects have their fundamental ideas in taking two doubled threads instead of two single ones, and having differences in the single threads to begin with followed up by differences again in the first doublings.

There may be a fine two-fold of, for example, moderate twist in first doubling, using the orthodox method of first doubling twist being opposite to first spinning twist. Its companion two-fold may be on the double spinning principle of doubling twist same way as spinning twist, and each just as much as experience dictates.

The first underlying principle is then much the same as for (*a*) above, so that the two doubled threads being twisted together, one goes harder and tighter, while the other goes slacker and softer and tends to give the spiral round the harder two-fold.

Snarled yarn, loop yarn, spot yarn, nep yarn, are other special effects sometimes required.

(*e*) No cotton novelty yarn attracted more attention during the bad trade period, 1920-21-22, than the gimp yarn used largely for sponge cloths and similar goods. For some time there was a very great demand so that ordinary ring-frames were often altered to produce certain sorts of gimp yarn. Other names, more or less in use for this yarn, are ratine, tuffle, sponge, and truffle.

Sponge cloth appears to be like voile cloth in having to stay, and be always more or less in demand.

A true gimp yarn has a very pronounced effect. The contraction and expansion effects above referred to are used very fully in a true ratine or gimp yarn, depending upon twisting and untwisting as required.

Hard and soft yarns, the use of coloured yarns, pronouncep spirals, definite knops, and such effects are introduced as required, and no cotton fancy yarn has for some years been more required than this.

(*f*) One of the easiest of novelty yarns is produced by intermittently giving extra speed to the back and middle rollers of the mule, and using just a single yarn. There are motions on the ring-frame for obtaining a somewhat similar effect by intermittently delaying the revolutions of front roller.

Professional designers have come to the conclusion that fancy effects in single and doubled cotton yarn can play a more important part than hitherto in meeting the requirements of cloth customers. This should be facilitated by closer contact between producer of fancy yarns, cloth manufacturers, and designers. The great demand for ratine or sponge cloth yarn forced this matter forward. Special effects in yarn may be obtained by "spinning down," and by departing much lower or higher than the twist standards. There is yet abundant room for new and greater effects in using "fancy" or novelty yarns in woven cloth, as distinct from depending alone and over-much upon Dobby motions and Jacquards at the loom.

Condenser yarns, printed yarns, preparation yarns, mixture yarns. mixtures of cotton with wool, linen, or silk produce special effects, It has been argued that single cotton yarns could be advantageously divided very much better into standard qualities and grades a little after the manner of raw cottons.

Yarns might be ordinary, medium, fair, good, super, etc. At present descriptions are comparatively loose and not sufficiently standardised as between one spinner and another.

Cocoanada gives a sufficiently deep and natural colour to yarn, so that before now it has passed instead of mild dyed yarn and has been very much cheaper. Deep brown Egyptian and red Peruvian have counted sometimes in a similar manner.

Off-coloured cottons, stained, tinged, have been at times judiciously used for certain dyed effects and have been bought cheaply because of the off-colour effect.

Final Grade. Cotton Spinning.

Section (a). Cardroom Processes, Syllabus, 1922-3.

The geographical positions of the cotton fields of the world; the area within which cotton can be commercially cultivated; the physical conditions necessary to its growth and their influence upon the character of the fibre. Minor cotton-fields. Possible cotton-fields.

Brief description of the characteristics, uses, and relative values of wool, silk, flax, jute, and other textile fibres.

The preparation of cotton for the market, including ginning, baling, packing and transport of cotton from the field to the factory, having reference to all cotton-growing and all cotton-spinning centres of the world. The influence upon mill processes and upon the finished yarn of faulty ginning and baling.

Classes and counts of yarn for which each variety of cotton is suitable. The cardroom treatment of dyed cotton, slivers, rovings, or other materials to produce special or fancy effects.

The terms and conditions on which raw cotton is bought; the method of selecting it when purchasing; the defects usually existing, and their effect upon the value. Tests for the moisture in cotton, and the permissible limit. The commercial purpose of mixing cotton. Testing of cotton for all usual purposes, at all processes in a cotton spinning mill, up to and including fly-frames.

The erection, repair, adjustment, practical manipulation, and general maintenance in good working order of all machines and accessories involved in cotton spinning, up to and including fly-frames. Defects in the work from any of the machines in this section; their causes, remedies, and effects.

Advanced features in the construction and working of all the machines referred to in previous paragraph. All differential motions for fly-frames; alterations for special purposes.

Cost of production and advanced calculations on the machinery and processes involved in section (*a*). Organisation and wage lists of blowing rooms and cardrooms.

The character and quantity of waste produced in the working of the machines and its utilisation. The construction, use, and manipulation of the machinery required in the preparation of cotton waste for spinning.

The selection, drafting, specification, methods of driving, proportioning, practical mill arrangements, setting-out, and starting-up of all machines required in a cotton spinning mill for the preparation of all qualities, counts, and descriptions of cotton roving.

The material, operations, and apparatus involved in roller covering; the preparation of drawing rollers for work and the accessory appliances used.

Section (b). Spinning and Subsequent Processes Syllabus, 1922-3.

The production of doubled yarns; the machinery used. The preparation of yarn for doubling; the characteristics of each variety. The modes of treating doubled yarn for different purposes and the machinery employed therein. Thread manufacture. The effect of different directions and amounts of twist and methods of twisting in both single and doubled yarns.

The production of fancy cotton yarns, such as corkscrewed, knop, and flake threads.

The uses to which cotton yarn is put. The characteristics required in cotton yarn for special purposes, such as hosiery, lace, sewing thread, crocheting, mercerising, and tyre yarns. Kinds and counts of yarn required for the leading lines of cotton or semi-cotton fabrics.

The terms and conditions of sale of yarn. Conditioning of yarn. Defects in yarn and their remedies. The testing of cotton yarns for all purposes.

The erection, repair, adjustment, practical manipulation and general maintenance in good working order of all machines used in spinning, doubling, and subsequent processes. Alteration of machines for special purposes. Horse-power required.

Methods of making up and packing cotton yarns, for various purposes and for various home and foreign markets. More advanced questions relating to winding, warping, reeling, bundling, preparing, polishing, and other processes subsequent to spinning. The process and machinery for cotton gassing.

Quantities and character of waste made and the utilisation of such waste. The final processes in the spinning of waste and the machines required. The character of the yarns produced and the purposes for which they are suitable.

The selection, drafting, specification, proportioning, methods of driving, practical mill arrangements, setting-out and starting-up of all machines employed in spinning and subsequent processes.

Advanced features in the construction and working of all the machines in this section, and particularly on the mule and ring-frame; defects in the work from any machines; their causes, remedies, and effects. Different mechanisms for producing equivalent results.

Cost of production, mill organisation, wage lists, and any advanced calculations on the machines and processes in this section.

Methods of lighting, heating, humidifying, ventilating, and fire prevention and extinction.

Textile Engineering and Cotton Economics are included in the same course, having separate classes and examinations.

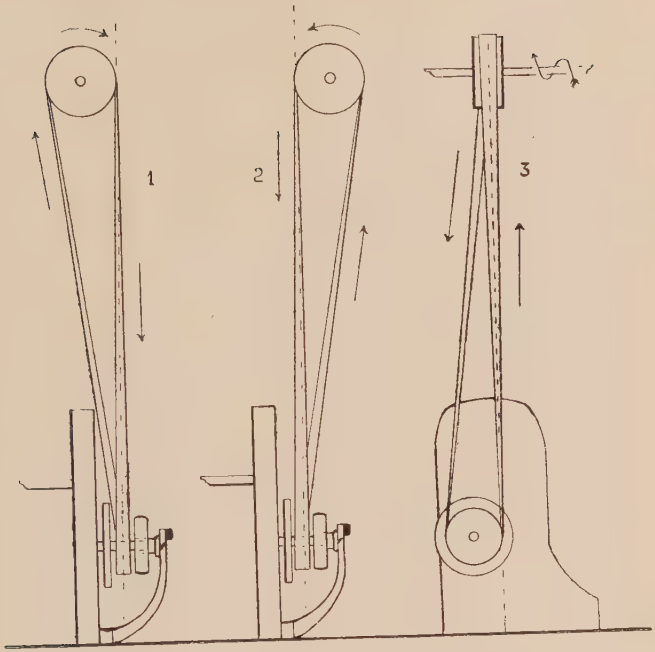


FIG. 175.—Settings. Part twisted drive.

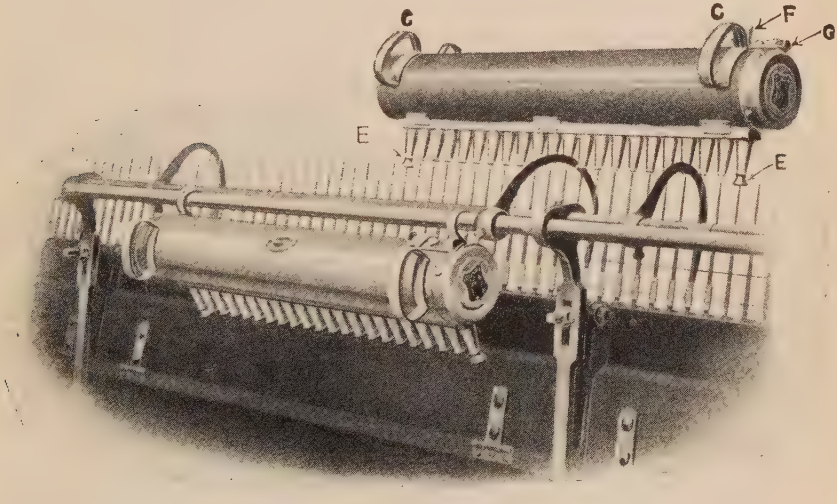


FIG. 176.—Tubing apparatus..

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